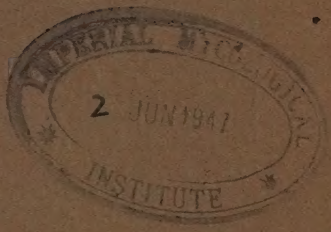
COMPTES RENDUS
(DOKLADY)
DE L'ACADÉMIE DES SCIENCES DE L'URSS

NOUVELLE SÉRIE

1943



VOLUME XXXIX

№ 9

ÉDITION DE L'ACADÉMIE DES SCIENCES DE L'URSS
MOSCOU

AVIS AUX AUTEURS

Les «Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS» paraissent tous les dix jours. Neuf numéros composent un volume pourvu d'une table des matières. Il y a quatre volumes par année.

Les «Comptes Rendus de l'Académie des Sciences de l'URSS» en de courtes communications précisent l'essentiel des travaux en préparation. Ces articles, ne dépassant pas en règle générale quatre pages, sont donnés en anglais ou en français. Ils embrassent les sciences mathématiques, physiques, naturelles et appliquées, mettant au jour les résultats de recherches scientifiques en cours ou qui viennent d'être achevées, et représentant ainsi les plus récentes données de l'investigation scientifique.

L'auteur a droit à 25 exemplaires de son article.

Adressez les manuscrits à la Rédaction des «Comptes Rendus», Kazan, rue Baumann, 19.

30 Juin

COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

COMITÉ DE RÉDACTION

A. Arbusov, de l'Académie, **A. Borissiak**, de l'Académie, **V. Chlopin**, de l'Académie, **A. Deborin**, de l'Académie, **A. Fersman**, de l'Académie, **A. Frumkin**, de l'Académie, **A. Kolmogoroff**, de l'Académie (vice rédacteur), **L. Orbeli**, de l'Académie (rédacteur en chef), **A. Richter**, de l'Académie, **S. Soboleff**, de l'Académie, **S. Wawilow**, de l'Académie (vice rédacteur)

NOUVELLE SÉRIE

11-me année

Paraissant tous les dix jours

1943

VOLUME XXXIX, № 9

TABLE DES MATIÈRES

Pages

MATHÉMATIQUES

N. Landkoff. On the Position of Irregular Points in the Generalized Problem of Dirichlet 335
L. Lusternik. On Dimensionality of Critical Sets 338
N. Tschebotaröw, Corresponding Member of the Academy. On a General Criterion of the Minimax 339

ASTRONOMIE

B. Fessenkoff, Member of the Academy. On the Origin of Zodiacal Light 342

ÉNERGÉTIQUE

K. I. Shenfer, Member of the Academy, and **P. A. Sviridenko.** Utilization of Energy of Internal Combustion Engines in their Testing 345

PHYSIQUE DU GLOBE

N. N. Sytinskaya. Sources of Sky Brightness and of Landscape Illumination during the Totality of a Solar Éclipse 348

CHIMIE

V. N. Ufimzev. On the Structure and the Properties of β-Naphthol Azodyes . . . 351
D. N. Vaskevich and **J. I. Baklazhez.** The Action of Emulsifying Agents upon the Stability of Synthetic Resins 354

CHIMIE PHYSIQUE

I. I. Breido and **G. N. Gorokhoysky.** Investigation of Desensibilizing Action of Optical Sensitizers 357

CHIMIE DU GLOBE

A. P. Vinogradov and **E. A. Boichenko.** Composition of Cellular Membranes in Recent and Fossil Lower Plants 360
L. M. Miropolsky and **S. A. Borovick.** Spectral Analysis Data on Calcium-Iron-Copper-Bearing Minerals and Native Sulphur from Tartary 365

GÉOLOGIE

V. I. Yavorsky. Devonian *Stromatoporellidae* and their Rôle in the Study of the Stratigraphy of the Kuznetsk Basin 369

MICROBIOLOGIE

A. J. Jolkevich. Experimental Inoculation of Lepra to White Mice Previously Made Sensitive by Filtrates of the Skin of Leprous Patients 371

Édition de l'Académie des Sciences de l'URSS
Moscou 1943

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

MATHEMATICS

ON THE POSITION OF IRREGULAR POINTS IN THE GENERALIZED PROBLEM OF DIRICHLET

By N. LANDKOFF

(Communicated by S. L. Soboleff, Member of the Academy, 11. I. 1943)

What we shall here for brevity sake describe as *curve of class A* is the space curve of Jordan satisfying the following two conditions:

1) *Every point of the curve, with the possible exception of the set of points of first category, is attainable by a cone. This will mean that every such point is the apex of a rotation cone having no common points with the curve in the neighbourhood of the apex.*

2) *The projection of the curve upon any plane (which presents a continuous curve) has no more than a denumerable number of multiple points*.*

The object of the present paper is to prove the following

T h e o r e m. *Let Ω be a three-dimensional region with boundary F, such that every Jordan curve lying upon F can be reached from outside by a surface. Then on every curve of class A lying on F irregular points form a set of category one.*

It may be remarked that the theorem seems to hold good when no restrictions whatever are imposed upon Jordan's curve. But the method we used is not fit to prove it in this general way.

1. If P is a point of F, then $c(\rho, P)$ will denote the capacity of intersection between a sphere of radius ρ with its centre at P and the complement to Ω. From the well known Wiener's criterion (1) it is not difficult to derive—what Kellog and Vasilesco did (2)—that the necessary and sufficient condition for the point P to be an irregular point is the convergence of the integral

$$I(P) = \int_0^1 \frac{c(\rho, P)}{\rho^2}\, d\rho.$$

The value of this integral, as a function of P, is semi-continuous from below. This remark permits to relax the formulation of the above theorem in the following way.

T h e o r e m. *With the same conditions imposed upon the region Ω every curve L of class A contains one regular point at least.*

2. This problem, when the monotony of the capacity is made us of, readily reduces to the following.

* Multiple points depending upon the parametric presentation of that continuous curve are here not taken into consideration. In other words, using the terms of Schoenflies not a «Bahnkurve», but a «stetige Kurve» is dealt with.

Being given a Jordanian surface S with edge L, prove that the regular points (i. e. regular for the solution of the outer problem of Dirichlet) lie everywhere dense upon L*.

Let us make use of the fact that *projecting the set upon a plane does not increase its capacity*. This follows, for instance, from the definition of the capacity as a transfinite diameter ([3]). Besides, the following obvious proposition will be used.

Let L be a closed curve of Jordan, forming the edge of a Jordan surface S. If another Jordanian curve L_1 is engaged with L so that it cannot be drawn into a point by continuous deformation without intersecting L, then L_1 necessarily intersects S.

We shall now prove an important particular case of our fundamental theorem and regard L as a *plane curve*.

If the part of the plane R_1 lying to one side of L is taken for the Jordanian surface, it may be easily seen that the regular points of R_1 lie everywhere dense on L. In fact, all points attainable by angles lying in R_1 will be regular and their set everywhere dense on L. From § 1 it follows that the irregular points of R_1 form a set of first category on L. The same reasoning applies to the other part of the plane, R_2, contiguous with L.

Hence the points of L irregular with respect to at least one of the parts of the plane, either R_1 or R_2, also form a set of first category. Now a point P upon L regular with respect to both parts of the plane, R_1 and R_2, will be considered in order to prove that this point *is regular for any Jordanian surface* S whose edge contains L. Surround P with a sphere of radius r and adopt the following notation:

$L(r)$, the connected part of the curve L, lying inside the sphere and containing the point P;

$S(r)$, the connected part of the surface S, lying inside the sphere and containing $L(r)$;

$m(r)$, portion of the edge of $S(r)$, lying on the sphere **;

$c(r)$, capacity of $S(r)$;

$c'(r)$, capacity of the part R_1 inside the sphere;

$c''(r)$, capacity of the part R_2 inside the sphere.

Let us evaluate $c(r)$ from below. Consider a circular cone K with its apex in P and its axis perpendicular to the equator (the plane in which L lies). The interval $0 < r \leqslant r_0$ can be subdivided into three sets A_0, A_1 and A_2. To A_0 we refer those values of r for which $m(r)$ has common points with the cone K. To A_1 (respectively, A_2) we refer the values of r for which $m(r)$ has no points in common with K and can without crossing the cone be changed by continuous deformation to the equator arc bounding R_1 (resp. R_2).

The set of numbers M within the interval $0 < r \leqslant r_0$ will for brevity sake be described as a *set of uniform leaps*, if it includes a sequence of numbers tending to zero $r_1 > r_2 > r_3 > \ldots$ such that $\frac{r_i}{r_{i+1}} <$ const for every i. Otherwise M is called a *set of increasing leaps*. Furthermore M is said to be regular at point O, if, denoting by $\mathfrak{M}$ the set of circumferences having their common centre at O and passing through the points of M, and by $K(r)$ the capacity of the part of $\mathfrak{M}$ lying inside the circle of radius r with centre at O, we have

$$\int_0 \frac{K(r)}{r^2}\, dr = \infty.$$

It may be remarked that for M to be regular it has merely to contain an infinite sequence of not intersecting intercepts $a_i \leqslant r \leqslant b_i$ $(i = 1, 2, 3, \ldots)$; moreover, $\frac{b_i}{a_i} \geqslant \varkappa > 1$.

---

* Outside any neighbourhood L surface S may be regarded as smooth .

** According to the preceding footnote, this curve is smooth at a positive distance from the equator.

Two cases are possible:

I. A_1+A_2 *is a set of increasing leaps* (it may also be void, as a particular case). Then A_0 is regular in O, what can be proved directly.

II. Suppose now that A_1+A_2 *is a set of uniform leaps*. It then contains a sequence $r_1 > r_2 \ldots$ tending to zero, for which $\frac{r_i}{r_{i+1}} < \text{const}$. We may further take it for granted that $\frac{r_i}{r_{i+1}} > a > 1$, because we can always arrange it so by extracting, if necessary, a subsequence.

Theorem. *On every plane curve of Jordan irregular points form a set of category one.*

3. Now let L be a *curve of class A* and contain no plane portions. Denote by $\overline{L}$ its projection on a certain plane. The set of points of L projecting into a multiple point of $\overline{L}$ is closed and nowhere dense on L, because L contains no segments. Therefore the set M of all points of L lying over multiple points is one of category one upon L. The projection $\overline{P}$ of any other point P on L can be surrounded by a neighbourhood V which is divided by $\overline{L}$ into two regions R_1 and R_2. In accordance with § 2, the set $\overline{X}$ of points of $\overline{L}$, irregular with respect to at least one of the regions R_1 and R_2, is a first category set on $\overline{L}$. Let us show that the prototype X of the set $\overline{X}$ on L is one of the first category on L. In fact, the number of arcs L projecting into the part of $\overline{L}$ lying inside V is finite. This follows from the fact that L, as a Jordanian curve, can have no limit continuum. Therefore the part X_V of the set X situated on these arcs is one of first category on L. Taking a sequence of neighbourhoods $V = V_1 \supset V_2 \supset V_3 \supset \ldots$ that can be drawn into the point P, and denoting by $X_{\overline{P}}$ the full prototype of $\overline{P}$ (this is not a dense set anywhere), we come to the conclusion that $X_{V_1}+X_{V_2}+\ldots$ $\ldots+X_{\overline{P}}$ is a set of first category. Now this set contains the full prototype of the part of X located within V. In a final way our statement is inferred from the fact that the set of all ordinary points of $\overline{L}$ may be involved in a denumerable system of neighbourhoods.

Thus, the set $X+M$ is of first category on L. We shall now consider a denumerable set of directions $l_1, l_2, \ldots$, situated dense everywhere, and determine the sets $X_1+M_1, X_2+M_2, \ldots$ corresponding to the projecting in these directions. Their sum N is also of first category on L. Therefore one may find a point Q on L not entering into N and attainable, moreover, by a certain cone K. Decreasing, if necessary, the angle of the cone, one may regard its axis as coinciding with one of the directions l_n. Besides K, consider another cone k with the same axis, but with a smaller angle.

Now as in § 2 it may be proved that for any surface adjoining L the point Q is regular. For the cone K, used in § 2, one has to take the cone k, and, in the case I of the proof, to examine the difference between the angles at the axial section through the cones K and k. In the case II the demonstration needs no modification.

Ukrainian State
University.

Received
8. X. 1942.

REFERENCES

[1] М. Келдыш, Успехи матем. наук, VIII (1939). [2] Kellog and Vasilesco, Amer. Journ. of Math., LI (1929). [3] Polya und Szegö, Journ. f. reine u. ang. Math. 165 (1931). [4] Wiener, Journ. of Math. and Ph., Mass. Inst. of Technol., III.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943, Volume XXXIX, № 9

MATHEMATICS

ON DIMENSIONALITY OF CRITICAL SETS

By L. LUSTERNIK

(Communicated by S. L. Soboleff, Member of the Academy, 27. I. 1943)

Certain problems of variation calculus involve the estimation of dimensionality of a critical set. Confining ourselves for the time being to the case of a function given on an n-dimensional manifold, we shall prove some propositions by means of which it is sometimes possible to estimate this dimensionality.

Let R be a twice differentiable n-dimensional manifold; f, a twice differentiable function given on R and having a finite number of different critical values, i. e. a finite number of values at critical points (for which $df=0$). In the following we shall consider homologies in R to a prime modulus p or to modulus 0. By q we denote, in the first case, any positive number less than p; and in the second, any positive number whatever. Let z be a certain cycle $(0\leqslant l\leqslant n)$ in R. Denote by $[z]$ the totality of cycles homologous to qz in R; by c_z; the lower boundary of maxima f in all cycles $[z]$; c_z is known to be a critical value of f.

The cycle x is said to be comprised in the cycle y (in R) if there exists a cycle z such that

$$yz \sim qx.$$

Denote by k, l; m the dimensionalities x, y; z. It is obvious that $k\geqslant l$ and $l+m=k+n$.

Theorem. *If $c=c_y=c$; the hypersurface $f=c$ contains a critical set whose dimensionality is not less than $l-k$. Moreover, it contains an $(l-k)$-dimensional cycle not homologous to zero.*

Suppose in fact, that $c_x=c_y=c$. There exists an l-dimensional cycle y_0 of class $[y]$ confined entirely within the closed region $f\leqslant c$. M will denote a critical set situated on the hypersurface $f=c$. If M contains no $(l-k)$ dimensional cycle not homologous to zero, then the cycle z can be «removed» from M (by virtue of Pontrjagin's theorem); i. e. there exists an m-dimensional cycle z_0; $z_0\sim z$; such that z_0 is all contained in M. We have

$$x_0=z_0y_0\subset[x].$$

As x_0 is entirely outside the critical set M; it may be deformed by customary methods to the region $f<c=c_x$. So there should exist a cycle of class $[x]$ all confined within the region $f<c_x$; which conclusion contradicts the definition of c_x. This proves the theorem.

It may be inferred from this reasoning that M does contain such an $(l-k)$-dimensional cycle and that $x(u;\ z)\neq 0$.

Evidently, the highest number of cycles in R inserted into one another coincides with the length of the manifold, as determined by Froloff and Elsholz [1].

Received
29. XII. 1942.

REFERENCES

[1] Froloff et Elsholz, Rec. Math., **42**, 5 637 (1935).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

MATHEMATICS

ON A GENERAL CRITERION OF THE MINIMAX

By N. TSCHEBOTARÖW, Corresponding Member of the Academy

Let a function

$$F(X, A) = F(x_1, x_2, \ldots, x_n; a_1, a_2, \ldots, a_r) \tag{1}$$

be given which depends on the coordinates of two points X, A which run over sets $M(X)$, $M(A)$ of the spaces $R(X)$, $R(A)$. The set $M(X)$ may be either discrete or connected, while the set $M(A)$ is supposed to be connected. The function (1)

a) is bounded and has continuous derivatives of the first and the second order with respect to $a_1, a_2, \ldots, a_r$;

b) the points of $M(X)$ which satisfy the inequality

$$f(X, A) > f_0$$

for a certain constant f_0 and for A lying in a neighbourhood of A_0, form a compact set.

Our purpose is to characterize the value $A = A_0$, for which the largest value of $f(X, A)$ with respect to X [which we shall denote by $\Phi(A)$] takes a minimum.

Theorem. *We denote by Y the vector with the components*

$$y_i = \frac{\partial F(X, A_0)}{\partial a_i} \qquad (i = 1, 2, \ldots, r). \tag{2}$$

Let $x^{(\nu)}$ $(\nu = 1, 2, 3, \ldots)$ be all vectors for which $f(X, A_0)$ takes the largest value:

$$f(X^{(\nu)}, A_0) = \Phi(A_0),$$

and let $Y^{(\nu)}$ be the corresponding vector Y. If for each arbitrary vector $C = (c_1, c_2, \ldots, c_r)$ we can find a pair of vectors $Y^{(\mu)}$, $Y^{(\nu)}$ for which the scalar products $CY^{(\mu)}$, $CY^{(\nu)}$ are of different signs, the function $\Phi(A)$ has a minimum at the point $A = A_0$. On the other side, if there exists a vector C for which all scalar products have the same sign, $\Phi(A)$ has no minimum at the point $A = A_0$.

Notice. The case when there exists vector C, for which all scalar products $CY^{(\nu)}$ are either zero or negative, is ambiguous and requires supplementary data.

Proof. The Taylor formula gives us:

$$F(X, A_0 + \varepsilon C) = F(X, A_0) + \varepsilon CY + \varepsilon^2 \sum_{i,k} \frac{c_i c_k}{2} \frac{\partial^2 F(X, A_0 + 0\varepsilon C)}{\partial a_i \partial a_k}. \tag{3}$$

If for each C we can find two products $CY^{(\mu)}$, $CY^{(\nu)}$ of different signs, then we choose $Y^{(\nu)}$ so that $CY^{(\nu)}$ is positive, and $\varepsilon > 0$ and so small that

$$|\varepsilon CY| > 2\left|\varepsilon^2 \sum_{i,k} \frac{c_i c_k}{2} \frac{\partial^2 F(X, A_0 + \vartheta\varepsilon C)}{\partial a_i \partial a_k}\right|. \tag{4}$$

Then it follows form the formula (3)

$$F(X^{(\nu)}, A_0 + \varepsilon C) > F(X^{(\nu)}, A_0).$$

This inequality shows that for each sufficiently small variation of A_0 the function (1) takes values which are larger than the maximum of (1) for $A = A_0$, i. e. than $\Phi(A_0)$. Thus, at $A = A_0$ the function $\Phi(A)$ has a minimum.

Now we suppose that there exists a vector C such that all products $CY^{(\nu)}$ are of the same sign. We choose the sign of C so that all $CY^{(\nu)}$ are negative.

Let a sequence

$$\varepsilon_1 > \varepsilon_2 > \ldots > 0, \quad \varepsilon_k \to 0$$

be given such that for $X = X_{(k)}$, $\varepsilon = \varepsilon_k$ (4) holds. It follows from (3) and (4)

$$F(X^{(k)}, A_0 + \varepsilon_k C) < F(X^{(k)}, A_0) + \frac{\varepsilon_k}{2} CY. \tag{5}$$

We suppose that $\Phi(A)$ has a minimum at $A = A_0$. Then for each sufficiently large k there exists a point $\overline{X}^{(k)}$ for which

$$F(\overline{X}^{(k)}, A_0 + \varepsilon_k C) \geqslant \Phi(A_0). \tag{6}$$

The set $\overline{X}^{(1)}, \overline{X}^{(2)}, \ldots,$ in virtue of b), has at least one limit point, say $\overline{X}$. It follows from (6) and a), since $\varepsilon_k \to 0$:

$$F(\overline{X}, A_0) \geqslant \Phi(A_0), \tag{7}$$

so that $\overline{X}$ must be one of the points $X^{(\nu)}$.

In virtue of the definition of $\Phi(A)$, we have

$$F(\overline{X}^{(k)}, A_0) \leqslant \Phi(A_0). \tag{8}$$

On the other side, since $\lim \overline{X}^{(k)} = X^{(\nu)}$, the inequality (4) and therefore (5) holds for $k \geqslant \nu$. If we apply (5) to the left-hand side of (6), we obtain:

$$F(\overline{X}^{(k)}, A_0 + \varepsilon_k C) < F(\overline{X}^{(k)}, A_0) + \frac{\varepsilon_k}{2} C\overline{Y}^{(k)}. \tag{9}$$

Then it follows from (8) and (6)

$$\Phi(A_0) < \Phi(A_0) + \frac{\varepsilon_k}{2} C\overline{Y}^{(k)},$$

i. e.

$$C\overline{Y}^{(k)} > 0, \quad CY^{(\nu)} = \lim C\overline{Y}^{(k)} \geqslant 0,$$

what contradicts our supposition about C, q. e. d.

Notice 1. The same criterium holds when we search for a maximum of $\Phi(A)$, while $\Phi(A)$ is the smallest value of $f(X, A)$.

Notice 2. Note that condition b) is inevitable only for the necessity of this criterion.

This criterion can be represented in a more convenient form. Let $Y^{(\nu)}(y_1^{(\nu)}, y_2^{(\nu)}, \ldots, y_r^{(\nu)})$ be the points in a space of r dimensions, and $c_1, c_2, \ldots, c_r$ be coefficients of an arbitrary hyperplane $c_1y_1 + c_2y_2 + \ldots + c_ry_r = 0$ which passes through the origin. We see that the minimax holds if and only if the points $Y^{(\nu)}$ lie on the two sides of each hyperplane passing through the origin. This means, in virtue of Carathéodory's theory (2), that the origin lies within the smallest convex body containing the points $Y^{(\nu)}$. This holds if and only if we can assign to $Y^{(\nu)}$ such masses that the origin be the centre of gravity of the heavy body obtained in such a manner.

This form of the criterion permits to represent it analytically:

$$\sum_{\nu} m_\nu Y^{(\nu)} = 0, \quad m_\nu \geqslant 0,$$

i. e.

$$\sum_{\nu} m_\nu y_i^{(\nu)} = 0, \quad m_\nu \geqslant 0 \quad (i = 1,2, \ldots, r). \tag{10}$$

Thus, it is necessary and sufficient for the minimax that the system of linear equations (10) have positive solutions $m_\nu \geqslant 0$.

As an example we consider the polynomials of degree n which deviate as little as possible from a given function $g(x)$ in the interval $(-1, 1)$:

$$F(x, A) = |a_0 + a_1x + \ldots + a_nx^n - g(x)|.$$

If for $A = A_0$ the maximum $\Phi(A_0)$ of the function $F(x, A)$ is realized at the points $x_1, x_2, \ldots, x_s$, then

$$y_k^{(\nu)} = \frac{\partial F(x_\nu, A_0)}{\partial a_k} = x_\nu^k \varepsilon_\nu \quad (k = 0, 1, \ldots, n),$$

where

$$\varepsilon_\nu = \operatorname{sign} F(x_\nu, A_0),$$

so that equations (10) have the form

$$\varepsilon_1 m_1 x_2^k + \varepsilon_2 m_2 x_2^k + \ldots + \varepsilon_s m_s k_s^k = 0 \quad (k = 0,1, \ldots, n).$$

This system has non-zero solutions only if $s > n+1$, i. e. if

$$s \geqslant n+2.$$

Now, if $x_1 < x_2 \ldots < x_s$, it is easy to see that this system has positive solutions if and only if the signs $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_s$ are alternatively $+1$ and -1. This is the well known criterion of Tchebycheff [see (1), p. 3].

It is easy to apply this criterion to the question of the smallest values which a quadratic form takes on for integer values of its variables (3), and also to analogous problems of Diophantine extrema. It is very probable that by suitably modifying its formulation, this criterion can be made to apply to some problems of functional analysis, calculus of variations, etc.

Received
6. III. 1943.

REFERENCES

(1) S. Bernstein, Leçons sur les propriétés extrémales etc., Paris (1926). (2) C. Carathéodory, Rendic. Circ. Mat. Pal., **32**, 193 (1911). (3) A. Korkine and G. Zolotareff, Math. Ann., **6**, 366 (1873); **11**, 242 (1877). See also Zolotareff, Oeuvres, I, 109 and 375 (1931).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

ASTRONOMY

ON THE ORIGIN OF ZODIACAL LIGHT

By B. FESSENKOFF, Member of the Academy

As I have shown, the greatest part of the asteroidal matter concentrated between the orbits of Jupiter and Mars is represented by very insignificant bodies, chiefly by cosmic dust. It is very probable that the scattering of the Sun's light by this matter is responsible for the broad diffuse band which may under very favourable conditions be observed along the zodiacal constellations.

Moreover, the well known Zodiacal Light—a feeble diffuse illumination in the sky, concentrated principally near the Sun and along the ecliptic, is certainly also produced by cosmic dust. Such a complex cannot be in a stable condition because of the radiation pressure. Consequently, the particles of dust must constantly originate in some part of the solar system. I tried to consider the origin of the Zodiacal Light, as well as the zodiacal band from a dynamic standpoint in the following way. The total surface of the asteroids is certainly very large and represents a considerable obstacle to the cosmic meteorites that generally pass through our system at hyperbolic velocities. As a result of their encounters with asteroids, fragments of such collisions are thrown out into the space.

It may be asked whether this process is capable of filling the space with particles of dust so as to account for the principal features of the phenomenon observed.

Let us suppose that a planet which is devoid of atmosphere, is revolving with a speed u around the Sun in a circular orbit of radius R. The particles of dust are thrown out of the planetary surface at certain relative velocities v_0 and with equal probabilities in all directions.

Assuming R and v_0 as given quantities, the trajectory of a particle passing at the point of space x, y, z is determined only by two parameters C_1, C_2 which are at our disposal. Giving them some small variations $(\Delta C_1, 0)$; $(0, \Delta C_2)$; $(\Delta C_1, \Delta C_2)$, one obtains three other trajectories of the same kind. Then at the same moment t the particles following these trajectories pass at the points (x, x_1, x_2, x_{12}). The density at the point (x, y, z) depending on the given parameters C_1, C_2 is then the inverse of the volume $V(x, x_1, x_2, x_{12}, v)$. The integral density at (x, y, z) is generally

$$\rho = \sum\sum \frac{P_1 P_2}{a^{3/2} V \ldots (x, x_1, x_2, x_{12}, v)}$$

where $P_1 P_2$ are the corresponding probabilities of these parameters. The semi-great axis a appears in the denominator, because the trajectory of every particle is independent of the mass.

This expression is very complicated and generally defies computation. Consider then two particular cases which admit a solution. One case is when the particles are emitted in the plane of the orbit of the generating planet or very near it, which determines the density in this plane. Another case is when the density in a normal plane is under consideration.

In the first case only one parameter is to be considered, for example, the angle γ between the absolute velocity of emmitting v_1 and the radius-vector r.

Suppose that the relative velocity v_0 is oriented with equal probability in all directions. Designating the correspondiug angle by ψ, one can see that

$$v_0 \cos\psi = v_1 \cos\gamma$$

and

$$P_\gamma = P_\psi \frac{\cos\psi\, d\psi}{\cos\gamma\, d\gamma}.$$

It follows that

$$P_\gamma = \frac{(k\sin\gamma + \sqrt{1-k^2\,\mathrm{soc}^2\gamma}\,)^2 \sin\gamma}{\{1-\cos^2\gamma\,[k^2\sin^2\gamma + 1 - k^2\cos^2\gamma + 2k\sin\gamma\,(1-k^2\cos^2\gamma)]^{\frac{1}{2}}\}^{\frac{1}{2}} + k\cos\gamma}$$

where

$$k = \frac{u}{v_0}.$$

In the particular case where $k=1$ we have simply

$$P_\gamma \propto \sin\gamma.$$

The density may be expressed in a form convenient for numerical calculation

$$D = \int \frac{P_\gamma d\gamma}{ar\sqrt{2ar - r^2 - ap}};$$

the quantity $p = a(1-e^2)$ is the parameter of a single elliptical trajectory passing at a point under consideration of the radius-vector r. It may be proved that D always has a maximum if $r=R$. The results of calculation are the following (Table 1).

Table 1

r	$v_0^2=1$	$v_0^2=2$	$v_0^2=3$	$v_0^2=4$
0.2	2.50	2.55	1.20	0.63
0.4	1.00	1.00	1.00	1.00
0.8	0.43	0.46	0.31	1.54
1.0	0.57	∞	∞	∞
1.2	0.32	—	0.25	1.24
1.6	0.09	—	0.052	0.41

It is admitted for convenience sake that $R=1$; $u=1$.

The inspection of this table and the analysis of the above-mentioned formula lead to the following conclusions.

Whatever the velocity of escape, the density is always a maximum at the distance of the generating planet. Very small or very great velocities leave the centre of the plane near the Sun devoid of matter. It is remarkable that all the velocities between u and $\sqrt{2}\cdot u$ lead to the same distribution of density in the central parts of our solar system. This distribution is a little more rapid than r^{-1}, being the same as observed in the Zodiacal Light. It is very probable that the whole complex of velocities gives nearly the same result.

Applying the same principle, it is possible to investigate the transverse section of the Zodiacal Light passing through the Sun. It is to be noted that in the transverse plane the particles passing near the Sun must have sufficiently small initial abso-

lute velocity v_1. It can be shown that in this case the density D at a distance z from the Sun is the following:

$$D = \int \frac{1}{v_1} \frac{d\alpha}{dz} P_{v_1} \frac{dv_1}{a^3};$$

here the angle of emission α is given approximately by the expression

$$\sin^2 \alpha = \eta (1 + v_1^2 \sqrt{\eta - \eta^2}), \quad \eta = \frac{z}{v_1^2}.$$

The value P_{v_1} is the corresponding probability of emission determined by

$$P_{v_1} = Ae^{-k^2(v_0 - v_m)^2}, \; v_1^2 = v_0^2 - u^2; \; v_m \ll 1.$$

The rate of the decrease of density is highly dependent on the coefficient k^2. For example, if $k^2 = 1.0$ or $k^2 = 10$, we have the following distribution along the axis z (Table 2).

Table 2

z	$k^2 = 1.0$	$k^2 = 10$
0.04	6.49	22.3
0.08	2.61	6.9
0.16	1.00	1.00
0.32	0.33	0.061
0.64	0.064	0.00118

Consequently, the dynamical theory of the Zodical Light can account for its principal features. The further working out of the theory must take into consideration the pressure of radiation.

Institute of Astronomy and Physics.

Received
12. IV. 1943.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

POWER ENGINEERING

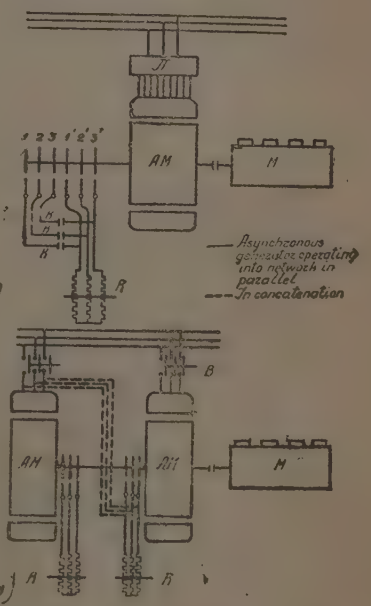
UTILIZATION OF ENERGY OF INTERNAL COMBUSTION ENGINES IN THEIR TESTING

By K. I. SHENFER, Member of the Academy, and P. A. SVIRIDENKO

The method of testing internal combustion engines as used at present in many factories is quite unsatisfactory in point of economy, because all of the fuel supplied is lost in the experimental set-up.

A rational solution of this problem is possible by means of mounting on the cylinder of the motor under test a load electrical generator. This generator has to produce power and to give it up into the network within a wide range of variation in the rotation number of the i. c. engine.

Description of Method. Difficulties are here likely to be encountered, however, because the change in the speed of the i. c. engines will cause to change the frequency of the electromotive force induced in the windings of the three-phase load generator which is mounted on the same cylinder with the engine of internal combustion. Under these conditions no work for electric network can possibly be done by the generator.



In America a way out of this difficulty has been found in the use of a hydraulic coupling which connects the i. c. engine to the generator and makes it possible to vary the speed of the former within a wide range (1). In another American set-up a sliding electric coupling is used instead of the hydraulic coupling, its operation being based on the action of eddy currents. But both of these methods make the installation more costly and complicated.

A simple solution of the problem, involving no use of a coupling, either hydraulic or electric; is proposed in the present paper.

According to this scheme (see figure; *a*), part of the energy expended in testing is recuperated, i. e. returned into the network. The symbols in this figure denote: *M*, motor of internal combustion engine; *AM*, asynchronous machine put into rotation by the i. c. e. *M* and working as asynchronous generator; *R*, rheostat in the rotor circuit; *K—K—K*, contactors; *1—2—3—1'—2'—3'*, contact rings; *II*, switch to change the number of poles in the stator winding of the asynchronous machine *AM*.

Asynchronous machines with a short-circuited rotor cannot work as a generator unless at nearly a constant speed.

In order to obviate this difficulty and make the asynchronous machine work as a generator at varying speed of the i. c. e. by which it is brought in rotation; one may recommend an additional resistance R inserted in the circuit of the rotor of the asynchronous machine, as is shown in figure, *a*.

Scheme of Installation. Let us give a comparative estimate of the three possible schemes of recuperation, whereby asynchronous machines with controlled resistance in the rotor circuit are used as generators of electric current.

1. One asynchronous machine without pole switch.
2. One asynchronous machine with its number of poles variable by switching.
3. Two asynchronous machines.

It may be remarked that according to the usually specified conditions of the test, the power on the cylinder of the i. c. e. grows with the speed.

The first, original, scheme (involving the use of only one asynchronous machine) is much the most simple, but at the same time the least efficient.

A more economic work of the installation is secured when the number of poles of this single machine is changeable by switching (figure, *a*). In an asynchronous machine with a phase rotor the change of the number of poles requires a corresponding switching-over not merely of the stator winding, but of the rotor winding as well (with its number of rings equal to that of outlets). Therefore the switching-over of the windings for more than two speeds is hardly advisable. In this respect it is convenient to choose a machine with the number of poles set by switching in the ratio 1 : 2. Such a machine will have 9 outlet terminals in the winding of the stator and 6 rings in that of the rotor (figure, *a*).

When the i. c. e. under test is running at a low speed, the windings of the stator and rotor of the asynchronous machine, which operates as a generator; should be switched to a large number of poles; and conversely, in the case of transition to a higher speed, the winding of the asynchronous machine should be switched to a smaller number of poles (two times as low).

The necessity of switching-over the stator and rotor windings can be altogether removed by using two asynchronous machines working in concatenation in the case of low speed and switched-over to the usual work in parallel in the case of higher speeds (figure, *b*).

With regard to efficiency, to the power factor and also to the amount of equipment, this scheme is somewhat inferior to the previous one. As, however, the replacement of a normal winding by a winding with variable number of poles is attended with practical difficulties, the scheme involving the use of two asynchronous machines is more simple, because no remounting whatever is required.

The here proposed set-ups with recuperation of energy into the network can be started both by an asynchronous motor and by an engine of internal combustion. Therefore in «cold-run» tests of i. c. e., which require a lower power on the cylinder, the same asynchronous machine can be used as an electric motor.

Power Control of Asynchronous Generator. For different speeds of rotation of the i. c. e. the power of the asynchronous generator (or of the two generators in the case of the third scheme) is controlled by changing the active resistance of the rheostat switched on in the rotor circuit. The control may be by hand, or at a distance, or automatic.

Considering the large number of speed steps and the condition of a simple and convenient handling, it appears desirable to unite the process of fuel supply to the i. c. e. with the process of changing-over the steps of resistance of the rheostat. This may be done by interconnecting the fuel supply sector with the handle of (or with the contactors controlling the resistance of) the rheostat.

From the well-known statements in the theory of asynchronous machines the power transmitted to the rotor by the rotating flux can be expressed by the equation

$$P_s = \omega_1 M = m (I'_2)^2 \frac{r'_2}{s}.$$

Substituting here approximately

$$(I_2')^2 \cong \frac{U^2}{\left(r_1 + \frac{r_2'}{s}\right)^2 + (x_1 + x')^2},$$

we find

$$P_s \cong \frac{mU^2}{\left(r_1 + \frac{r_2'}{s}\right)^2 + (x_1 + x_2')^2} \frac{r_2'}{s},$$

where U is voltage of one phase of the stator; m, number of phases; r_1, active resistance of one phase of the stator; r_2', active resistance of a rotor phase referred to the primary circuit; M, torque; $\omega_1 = 2\pi f_1$, angular velocity of a. c.; f_2 number of a. c. periods per second; x_1, reactive resistance of a stator phase; x_2', reactive resistance of a rotor phase; s, slip; I_2', reduced value of the current in the rotor phase.

The value of the torque is determined from

$$M \cong \frac{P_s}{\omega_1} = \frac{mU^2}{\omega_1 \left[\left(r_1 + \frac{r_2'}{s}\right)^2 + (x_1 + x_2')^2\right]} \frac{r_2'}{s}. \qquad (1^*)$$

If additional resistance R is inserted in the circuit of every rotor phase, then the torque is described by the equation

$$M \cong \frac{mU^2}{\omega_1 \left[\left(r_1 + \frac{r_2' + R'}{s}\right)^2 + (x_1 + x_2')^2\right]} \frac{r_2' + R'}{s}, \qquad (2)$$

where R' is reduced resistance

$$R' = R \frac{m_1}{m_2} \left(\frac{k_1 w_1}{k_2 w_2}\right)^2;$$

m_1, number of the stator phases; m_2, number of the rotor phases; k_1, winding factor of the stator winding; k_2, winding factor of the rotor winding; w_1, number of turns in a stator phase; w_2, number of turns in a rotor phase.

From equation (2) it is evident that by changing the resistance R', one may influence the value of the torque M and, accordingly, that of the slip s, while testing the i. c. e. In the case of regenerative work, the slip s enters into (2) with the negative sign.

Krzhizhanovsky Power Engineering Institute.
Academy of Sciences of the USSR.

Received
16. III. 1943.

REFERENCES

[1] G. E. Cassicy, General Electric Review, p. 590 (1941). [2] C. A. Chayne, Power Plant Engineering, May (1942). [3] К. И. Шенфер, Асинхронные машины (1938). [4] Morgan, W. Brown, A. Schramer, El. Engineering, p. 464 (1941).

* Equation (1) relates to the case of a two-polar machine. For a multipolar machine having p pairs of poles, the value of the torque M is obtained by multiplying by p the right member of equation (1).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

GEOPHYSICS

SOURCES OF SKY BRIGHTNESS AND OF LANDSCAPE ILLUMINATION DURING THE TOTALITY OF A SOLAR ECLIPSE

By N. N. SYTINSKAYA

(Communicated by S. I. Wawilow, Member of the Academy, 23.II.1943)

It has often been suggested in works on the photometry of solar eclipses, that the light of the corona is the chief source of the illumination of the landscape and the sky during the totality. The measuring of the integral brightness of the corona by means of an apparatus with a large field of vision, embracing together with the corona a considerable part of the sky, is justified by this point of view. If the sky light were really due to the scattering of the corona rays, it would be proportional to the light of the corona and, therefore, it would not influence the result of the comparison of the integral brightness of the corona with that of the Sun or the full Moon.

As a matter of fact, the brightness of the sky and the illumination of the landscape during the total eclipse is more than the light of the corona could give; consequently, there is no doubt that other sources of light are present here.

In the first line it is the manifold scattered light penetrating into the region of the lunar shadow from the parts of the atmosphere, from which the eclipse is only a partial one. Therefore, it is very important to determine the part which the light of the corona plays in the general illumination during the totality. In order to clear up this question, the photometric expedition of the Astronomical Observatory of the Leningrad University carried out special photometric measurements during the eclipse of 1936 in the village Bartat (1) of the Krasnoyarsk region.

The measurements have shown that the light of the sky during the total eclipse was so bright that only an insignificant portion of it could, possibly, be due to the light of the corona. However, the conditions of the weather during the observations were so unfavourable that this conclusion remained under doubt; so much the more, that Richtmeyer found during the «long» eclipse of 1937 that the light of the corona, though very weak, makes up nevertheless 4% of the general illumination.

In order to solve this question, a series of observations were carried out during the solar eclipse on 21st of September, 1941. This time the weather at Alma-Ata, where the observations of the expedition of the Leningrad University were carried out, was quite cloudless; so the obtained results do not excite any doubt.

The absolute measurements of the brightness of the sky were made photographically. Two cameras without object-lenses were used for that purpose. They were directed to the sky at the altitude of the Sun at the distance of 10° to the right and to the left from it. The brightness of the sky expressed in «daylight stilbs» was obtained from the photometric treatment of the negatives. It appeared that the sky near the Sun had a brightness equal to 2.1×10^{-4} sb. Moreover, the brightness

for the zenith was found equal to 0.9×10^{-4} sb. The observations made with the same apparatus and at the same altitude of the Sun without any eclipse gave for the given points of the sky the values equal to 3.1 and 1.6 sb, respectively. Thus, the decrease of the brightness of the sky at the totality was for the zenith 1800 times and for the places near the Sun 1500 times, whereas the integral brightness of the corona with regard to the Sun was during the same eclipse only 5.3×10^{-7}. Hence it follows that the scattered light of the corona during total eclipse could give no more than 0.1% of the general brightness of the sky. The same result is obtained after the visual observations of the brightness of the sky, carried out by I. M. Shaukenov (2). Those observations gave for the regions near the Sun 2.2×10^{-4} sb., i. e. 1750 times less than the visual brightness of the sky without eclipse under the same conditions.

Eclipse	Duration	Method of observation	Point of sky observed	Ratio of sky brightness with and without eclipse	Reference	Ratio of corona light to Sun light	Reference	Ratio of scattered corona light to whole sky brightness
1936	150 sec.	Visual	Clear sky, disk of the Moon . . .	5.0×10^{-1}	1	3.8×10^{-7}	1	0.76×10^{-3}
1936	150 »	Photogr.	Mean brightness of the cloudless parts of the sky	2.6×10^{-4}	9	3.8×10^{-7}	9	1.4×10^{-3}
1936	150 »	»	Mean brightness of the clouds . . .	1.2×10^{-4}	8	3.8×10^{-7}	9	3.2×10^{-3}
1936	150 »	Visual	Clouds at zenith .	1.8×10^{-4}	10	3.8×10^{-7}	1	2.1×10^{-3}
1941	120 »	»	Cloudless, 10° from the Sun	5.7×10^{-1}	2	4.6×10^{-7}	2	0.79×10^{-3}
1941	120 »	Photogr.	Do	6.8×10^{-4}	—	5.2×10^{-7}	—	0.78×10^{-3}
1941	120 »	»	Cloudless, zenith .	5.7×10^{-4}	—	5.2×10^{-7}	—	0.90×10^{-3}

The main result obtained for the two eclipses by comparing the brightness of the sky with the light of the corona are brought out in the table. In the process of tabulation a part of the data for the eclipse of 1936 was treated anew. It may be seen that the brightness of the sky which can be referred to the scattered light of the corona is of the order of 10^{-3} of the general brightness.

We are brought to such a conclusion also on the ground of the examination of photometric materials obtained during the previous eclipse. So the brightness of the sky during the totality of 1918 and 1925 was after Kunz and Stebbins (3) 5500 times less than that without the eclipse, whereas the light of the corona during these eclipses was, according to the data of Pettit and Nicholson (4), only 10^{-6} of the light of the Sun. The total illumination of the horizontal surface was found to be equal to 2.5 lux at the eclipse of 1925, and it was equal to 1.5 lux at the eclipse of 1926.

It thus exceeded 1000 times the illumination which could be provided by the light of the corona. The brightness of the sky during the eclipse of 1927 in Sweden was 1780 times lower as compared to the daylight brightness, while the light of the corona, according to the observations of B. G. Fessenkoff(5), was 1.4×10^{-7} of the solar light. A high brightness of the sky was also obtained by Aldrich(6) in 1918, and by Ross in 1922.

We may infer from the above that:

1. The part of the corona light in the total brightness of the sky and in the illumination of the earth landscape is very insignificant.

2. The study of the brightness of the sky or of the illumination of an open surface adds nothing to the knowledge of the brightness of the corona itself.

3. Only those observations in which the diffuse sky light is quite excluded can give real results as to the intensity of the light of the corona.

4. Since the spectrograms of the sky light at the totality, as obtained in 1936 by Link ([7]) in Sara and V. A. Ambarzumian near Krasnoyarsk, did not display any bright lines or bands, it was possible to conclude that the sky light in the region of the lunar shadow was due only to the scattering of the rays penetrating there from the surrounding zone of the partial eclipse.

Leningrad University Branch.
Elabuga.

Received
23. II. 1943.

REFERENCES

[1] В. Шаронов, Тр. экспедиций по наблюдению солнечного затмения 1936 г., **1**, 71 (1937). [2] В. Шаронов, Астр. журн., **29**, № 1 (1942). [3] Kunz and Stebbins, Astroph. Journ., **62**, 126 (1925). [4] Pettit and Nicholson, ibid., **62**, 202 (1925). [5] В. Фесенков, Тр. Гос. Астрофиз. ин-та, **4**, № 2 и 8 (1927). [6] Aldrich, Smithsonian Miscell. Coll., **69**, No. 9 (1919). [7] Link. Mem. and Obs. of the Czech. Astr. Assoc. at Prague, No. 5 (1937). [8] И. Васильев, Уч. зап. Ленингр. ун-та, **22**, 176 (1938). [9] Н. Сытинская, там же, **22**, 128 (1938). [10] Н. Фатчихин, там же, **22**, 154 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

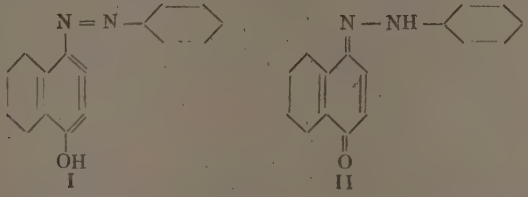
CHEMISTRY

ON THE STRUCTURE AND THE PROPERTIES OF β-NAPHTHOL AZODYES

By V. N. UFIMZEV

(Communicated by A. E. Porai-Kochitz, Member of the Academy, 29.I.1943)

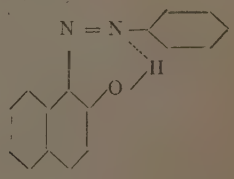
The production of one and the same azodye either from a diazonium compound and phenol or from an aryl hydrazine and quinone (1) has made the basis for expressing their structure in the azo (I) or hydrazone (II) form. Kuhn and Bär(2) spectroscopically investigated the simplest *p*-azodyes of the α-naphthol series and found out that in solution there exists an equilibrium between the two tautomeric forms



I II

which is shifted towards the one or the other side according to the nature of the solvent used.

There is no single point of view upon the structure of β-naphthol azodyes, nor upon their analogues—the *o*-azodyes of the α-naphthol series. Auwers (3) ascribes to them a normal azostructure, Burawoy and Markowitsch (4), a hydrazone structure and Kuhn and Bär accept an equilibrium between the two forms, only shifted more towards the hydrazone structure than in the case of *p*-azodyes of the α-naphthol series. Somewhat apart stands the opinion of Pfeiffer et al. (15) on the existence of a partial valence (chelated bond) in the case of β-naphthol azodyes. Their opinion is based upon the following structure:



However, the spectra of these *o*-azodyes are quite different from the spectra of true azoforms (ethers and esters). Moreover, it proved to be impossible to find in them symptoms of an equilibrium between the azo and the hydrazone form, which is a fact well established by the above-mentioned researches of Burawoy, Kuhn and Bär, and by the work of other investigators.

The comparison of the physical properties of *o*- and *p*-azodyes of the naphthol series shows that:

a) The simplest representative of the *o*-series of azodyes; 1-benzene-azo-2-naphthol, is easily sublimated and can even be distilled (6); differing from its isomer 4-benzene-azo-1-naphthol.

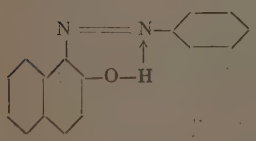
b) The melting points of *o*-azodyes are below those of *p*-azodyes, but in the case of their acetates (which have no chelated bond) this difference is smoothed out.

c) *o*-azodyes of the naphthol series, as different from *p*-azodyes, are insoluble in dilute alkalies, this being one of the main arguments in favour of the hydrazone structure of the former.

Table 1

Diazocomponent	*p*-azodye from α-naphthol		*o*-azodye from β-naphthol		Difference in melting points	
	dye m. p.	ester m. p.	dye m. p.	ester m. p.	dyes	esters
Aniline	206	128	134	117	72	11
2-bromoaniline	183	123	165	157	18	34
3-bromoaniline	211	112	172	88	39	24
4-bromoaniline	238	141	173	136	65	5
4-nitroaniline	279	166	252	162	27	4
4-toluidine	210	102	135	99	75	3

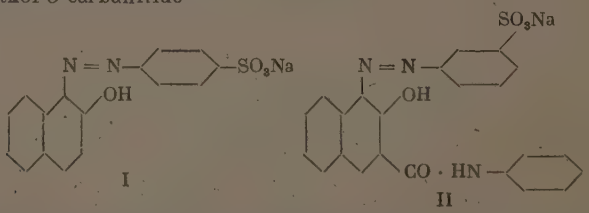
The first two properties can easily be explained if the chelated structure be accepted:



conformable to the conceptions of Pfeiffer and collaborators. But the insolubility of these *o*-azodyes in solutions of alkalies is hardly compatible with chelated structure; which is no serious obstacle to the formation of salts (for instance, *o*-nitrophenol, 1-nitroso-2-naphthol, quinizarine). A possible reason for the insolubility of these dyes in dilute solutions of alkalies is the poor solubility in water of the dye itself, this shifting the reaction in an inverse direction to the one expected:

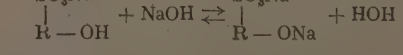
$$[R \cdot OH] + Na^{\bullet} + OH' \leftarrow R \cdot O' + H^{\bullet} + Na^{\bullet} + OH' \leftarrow R \cdot ONa + HOH.$$

Therefore as an object for investigation the following dyes were selected: 1-(*p*-benzene-azo-sulphonic acid)-2-naphthol (orange II) and 1-(*m*-benzene-azo-sulphonic acid)-2-naphthol-3-carbanilide



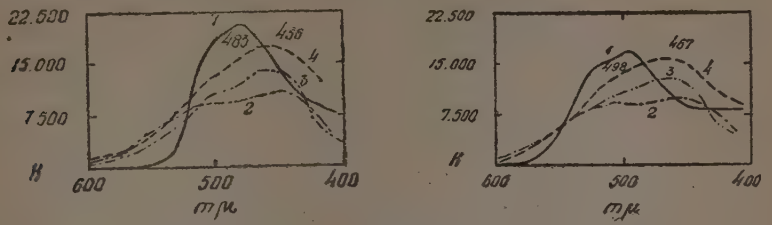
which contain a sulphonic acid group in the benzene nucleus; which circumstance should increase the solubility of the dye itself in water and thus remove the negative influence of its poor solubility upon salt formation.

These dyes which were investigated spectroscopically exist in a neutral aqueous solution in the form of initial monosodium salts (curves *1*), while in an alcohol solution of sodium ethylate they are present as disodium salts (curves *2*). In aqueous (curves *2*) or alcohol (curves *3*) alkaline solutions these two forms are in equilibrium:



Therefore in the spectra of the latter solutions a broad diffused maximum of absorption is observed, corresponding to the equilibrium of the two salts existing simultaneously. Such a marked formation of disodium salts is observed even

in weak solutions of sodium hydroxide (beginning with 0.01 norm. solution); and the usual notions concerning the difficulty of formation of salts in the case of *o*-azodyes of the naphthol series are erroneous.



Absorption curves for solution of sodium salts:

I—1-(*p*-benzene-azo-sulphonic acid)-2-naphthol salts; II—1-(*m*- benzene-azo-sulphonic acid)-2-naphthol-3-carbanilide. *1*, in a neutral aqueous solution; *2*, in a $^1/_3$ norm. aqueous solution of sodium hydroxide; *3*, in a $^1/_3$ norm. solution of sodium hydroxide in 92% alcohol; *4*, in a solution of sodium ethylate in dry alcohol (2% Na)

The monosodium salt of 1-(*p*-benzene-azo-sulphonic acid)-2-naphthol $C_{16}H_{11}N_2O_4SNa$ crystallizes from water; the disodium salt $C_{16}H_{10}N_2O_4SNa_2 + 2H_2O$ crystallizes from alcohol after the addition of sodium ethylate in the form of thin bluish-red needles. The monosodium salt of 1-(*m*-benzene-sulphonic acid)-2-naphthol-3-carbanilide, $C_{23}H_{16}N_3O_5SNa + H_2O$, crystallizes from water as brilliant red-orange needles; the disodium salt, $C_{23}H_{15}N_3O_5SNa + 1.5H_2O$, crystallizes from alcohol after the addition of sodium ethylate in the form of fine dark-red rhombic plates. The spectroscopic measurements in $^1/_{15000}$ norm. solutions of these dyes were carried out on a spectrodensograph of Goldberg.

Table 2

	Maximum of absorption		Shift of the maximum of absorption
	for the dye	for the salt	
4-benzene-azo-1-naphthol (7):			
enol form	406	—	—
hydrazone form	467	498	+ 31 mμ
1-(*p*-benzene-azo-sulphonic acid)-2-naphthol	483	456	— 27 mμ
1-(*m*-benzene-azo-sulphonic acid)-2-naphthol-3-carbanilide	498	467	— 31 mμ

The difference in the structure of *o*- and *p*-dyes is also apparent from the character of the shift of the absorption maximum that takes place upon the formation of the salt and its ionization. In the case of *p*-azodyes the shift is toward the long-wave side, whereas in the case of *o*-azodyes investigated by us the maximum of absorption is shifted towards the other side, this being easy to explain if chelated structure be accepted for them.

Voroshilov Scientific Institute
of Organic Semi-Manufactured
Products and Dyes.

Received
29. I. 1943.

REFERENCES

[1] Th. Zwicke u. H. Bindewald, Ber., **17**, 3026 (1884). [2] R. Kuhn u. F. Bär, Ann., **516**, 143 (1934). [3] K. v. Auwers, Ann., **360**, 11 (1908); K. v. Auwers u. P. Hanke, Ber., **61**, 1030 (1928). [4] A. Burawoy u. J. Markowitsch, Ann., **503**, 180; **504**, 71 (1933); A. Burawoy, Ann., **509**, 60 (1934); **521**, 298 (1936). [5] P. Pfeiffer, O. Angern, L. Wang, R. Seydel u. K. Quehl, Journ. f. prakt. Chem., [2], **126**, 97 (1930). [6] C. Liebermann, Ber., **16**, 2859 (1883). [7] H. Shingu, Sci. Papers Inst. Phys. Chem. Research, **35**, 106, 112 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

CHEMISTRY

THE ACTION OF EMULSIFYING AGENTS UPON THE STABILITY OF SYNTHETIC RESINS

By D. N. VASKEVICH and J. I. BAKLAZHEZ

(Communicated by A. E. Porai-Kochitz, Member of the Academy, 2. II. 1943)

Usually the emulsions of synthetic resins are stable for many days. While investigating aqueous emulsions of a synthetic resin, the condensation product of phenol, formaldehyde and dicyandiamide, we often observed the emulsion to separate into layers when the amount of dicyandiamide in the reaction mixture was above 0.7 mole per 1 mole of phenol. Technological difficulties that arose forced us to investigate this problem in detail.

The method for the production of such resins was worked out by one of us previously (2). 36 g of phenol were condensed for 2 hrs at 60° with 90 g of 36% formalin; 2 g of sodium hydroxide were used as catalyst. The condensation was carried out on a water bath in a flask with a reflux condenser. After 2 hrs 96 g of dicyandiamide and 120 g of 36% formalin were added to the reaction mixture. Simultaneously an emulsifying agent was added, from 1 to 10% from the weight of phenol. The condensation was over after 2 hrs at 80°. A homogeneous emulsion resulted the stability of which was investigated. It seemed worthy of interest to follow the emulsifying action of a compound containing functional groups of a different type—hydroxyl groups and acid groups. For this reason when looking for an emulsifying agent we selected Turkey-red oil, the Na-salt of sulphoricinoleic acid. Special experiments showed that under these conditions the emulsifying agent enters no reaction.

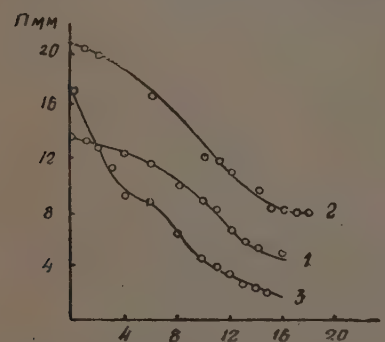


Fig. 1. Number of days from beginning of experiment

As a method for controlling the stability we selected the determination of the «water number» (2), i. e. of the amount of water which it is necessary to add to the resin in order to make it separate into layers. We connected the appearance of turbidity, i. e. of the separation of phases; with the decreasing hydrophilic properties of the resin, and the action of the emulsifier with a decrease of the difference in surface tension between the dispersion medium and the particles of the resin formed.

Fig. 1 shows the coagulation curves of the resins. The determination of the «water number» was carried out once a day. The resins were kept at a temperature

of 20°±1°. Along the abscissa axis the time from the beginning of the experiment is plotted and along the ordinate—the number of cm³ of water, bringing about the appearance of turbidity in 5 cm³ of the resin. Curve *1* refers to a resin prepared without an emulsifying agent, curve *2* to a resin with 2% of the emulsifier, and curve *3* to a resin with 3% of the emulsifier. Whereas the resin with 2% of the emulsifying agent is more stable than the control resin (curve *1*), the resin with 3% of the emulsifier already after 4 days becomes less stable than the control resin. All the three curves have an ogee-shape usual for coagulation curves. Thus; a small difference in the amount of the introduced emulsifying agent brought about a sharp change in the properties of the resin.

In this connexion we subjected the question to a more detailed study. A series of resins was prepared according to the method described above. The resins differed from one another in the amount of the emulsifying agent. From 1 to 10% of Turkey-red oil, calculated to the weight of the phenol, or from 0.11 to 1.08%; as calculated for the total reaction mixture, were introduced.

For all the resins immediately after condensation viscosity, according to Ostwald, was determined at 4 temperatures (20, 40, 60 and 80°; accuracy 0.1°).

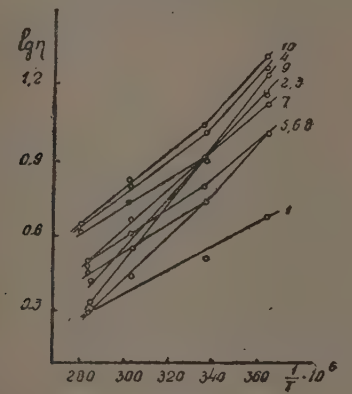


Fig. 2

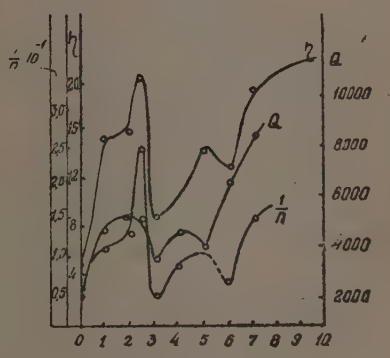


Fig. 3. Emulsifying agent, p. c. from weight of phenol

The relation between viscosity and temperature was the usual and had the form of an exponential curve. From the data obtained the heats of association of particles of the resin were determined according to Bernal and Ward ([3]). Fig. 2 shows the corresponding straight lines, the number of the straight line being one unit less than the percentage of the emulsifying agent added. All the straight lines proved to consist of two parts, thus showing a variable degree of aggregation. We connect this, in analogy with other synthetic resins ([4]), with two processes taking place simultaneously: the aggregation of primary particles into micelles of an eucolloid type and with a secondary bond between micelles. From the inclination of the straight line the heats of aggregation were calculated.

Fig. 3 shows the values obtained. Along the ordinate axis are plotted the viscosities of the corresponding resins at 20°, the heats of association and the inverse values of the threshold of coagulation, or of the water value. The peculiar form of the curves with two maxima and two minima should be noted. Besides, the maxima and the minima on each of the curves coincide corresponding to one and the same amount of the emulsifying agents for all the curves.

It seems that the most simple way to explain the facts observed is the following one (see scheme in Fig. 4 which expresses the possible states corresponding to the different amounts of the emulsifying agent added). State I corresponds to the resin obtained without any emulsifying agent. Large parti-

cles of irregular form denote the particles of the resin, small ones—the dispersion medium. The introduction of small amounts of the emulsifying agent leads to a partial protection of the surface of the resin particles. Their surface energy is distributed in such a manner that two or more particles of the resin form an unstable complex (state II, Fig. 4). In this case the viscosity of the resin should be greater and the heats of aggregation also greater and the threshold of coagulation lower. This corresponds to the first maximum (Fig. 3). A further increase in the amount of the emulsifying agent lead to the protection of the whole surface of the particle and the decomposition of the

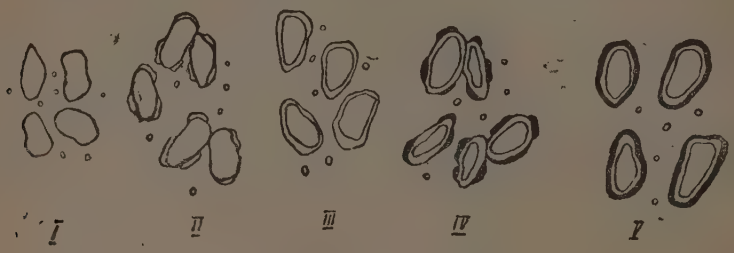


Fig. 4

complex (state III, Fig. 4). In this case the viscosity and the heats of aggregations should be less than in state II, but larger than the initial ones. Correspondingly, the threshold of coagulation should also be higher. All this can be observed in practice in Fig. 3. When the addition of the emulsifying agent continues, the presence of different functional groups in it becomes manifest. Whereas in states II and III in Fig. 4 protective action was produced only by functional groups of one kind, later on those of the other kind also should begin to act. The resin particles act in state III as charged oppositely compared to the initial state. Accordingly, the sorption of the emulsifying agent by the particle takes place and its orientation on the surface of the resin particle. States IV and V are virtually analogous to states II and III, except that the surface is oppositely charged. Accordingly, there appears in Fig. 3 a second maximum and a second minimum, but neither of them is so sharply expressed.

Conclusions

The stability of a synthetic resin on the basis of the condensation products of phenol, formalin and dicyandiamide has been studied. It has been found that the stability of such a resin depends greatly upon the amount of the emulsifying agent added.

The use of an emulsifying agent with different functional groups (SO_3Na and COOH, on the one hand, and OH, on the other) leads to a peculiar form of the viscosity, heat of aggregation and threshold of coagulation curves which have their maxima and minima dependent on the amount of the emulsifying agent added.

A model scheme has been proposed explaining this form of the curves and consisting in the formation and decomposition of unstable complexes of the resin and in the change of the sign of the charge of the particle's surface.

Institute of Organic Chemistry.
Academy of Sciences of the USSR.
Experimental Plant of Plastics.

Received
2. II. 1943.

REFERENCES

[1] А. И. Асташенко, В. С. Кулешов и Д. Н. Васкевич, Авторское свидетельство 59027 от 28 II 1941. [2] Сборн. «Пластические массы», 2, 244 (1937). [3] A. G. Word, Trans. Farad. Soc., 33, 88 (1937). [4] Д. Н. Васкевич и В. С. Долина, Колл. журнал, 7, 291 (1941).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

PHYSICAL CHEMISTRY

INVESTIGATION OF DESENSIBILIZING ACTION OF OPTICAL SENSITIZERS

By I. I. BREIDO and G. N. GOROKHOVSKY

(Communicated by S. I. Wawilow, Member of the Academy, 19.XII.1942)

As a rule, a photographic emulsion lowers its natural sensitivity in sensibilizing dyes. This desensibilizing effect may be interpreted in two ways. The first explanation is that the dye adsorbed by the emulsion crystals directly affects the process of formation of centres of the latent photographic image, which is known to proceed near the surface. If so, the sensibilizing action of dyes is very similar to that of bromine ions (1) and is not therefore likely to bear a spectral selective character. According to the second explanation, a filter effect takes place in the region of natural sensitivity, very similar to that observed by one of us (2) in the region of additional sensitivity with high concentration of the dyestuff. Inasmuch as the way made by the ray inside the heterogeneous emulsion layer may, owing to many reflections, be a rather long one, the filter effect may be fairly considerable even in an emulsion containing no great quantity of dyestuff. In that case the desensibilizing action of the dyestuff will be of spectrally selective nature.

At this juncture the question is still obscure. The latter explanation of the desensibilizing action of dyestuffs was subjected to a thorough criticism by Lüppo-Cramer (3). At the same time, Rabinovich and Skchetinkina (4) have observed the maximum of natural sensitivity of the emulsion to shift as the concentration of the dyestuff in it is growing, which seems to point to the existence of a filter effect.

In order to clear up this question, we undertook to investigate the spectral distribution of the natural sensitivity of both low-sensitive and high-sensitive layers, previous to sensibilization and after they have been sensibilized by bathing in solutions with different concentrations of the dyestuff (lower or higher than the optimum of sensibilization). The dyestuffs were selected to represent different chemical structures and different spectrum regions of sensibilization. As sensitizers for the yellow-red region of the spectrum pinacyanol and thiacarbocyanine dye № 11 of the Kharkov Institute of Applied Chemistry (5) were investigated. Among infra-chromatic sensitizers we chose: kryptocyanine; neocyanine and xenocyanine ($\lambda_{max} = 960$ mμ). The composition of the solvent was $H_2O : C_2H_5OH = 3 : 2$. In order to determine their energetical spectral sensitivity in the ultra-violet and violet regions of the spectrum (6), the sensibilized plates were exposed in a quartz spectrograph with a quartz mercury arc as light source. The resulting curves ($\lg S_\lambda = f(\lambda)$) were obtained for 7 points corresponding to the most intense lines of the mercury spectrum ($\lambda = 253$—436 mμ).

Irrespective of the dyestuff, of the photographic material and of the concentration of the sensibilizing bath the results of all tests were similar. Though different dyes show a different absolute value of desensibilizing action, yet, as may be seen e. g. from Fig. 1 and 2, the logarithmic curves of spectral sensitivity in the whole

region of natural sensitivity shift; as a result of sensibilization; parallel to themselves in the downward direction. The departures from parallelism (i. e. from the constancy of the quantity $\Delta \lg S_\lambda$, see e. g. Fig. 3) lie within the accuracy of spectral

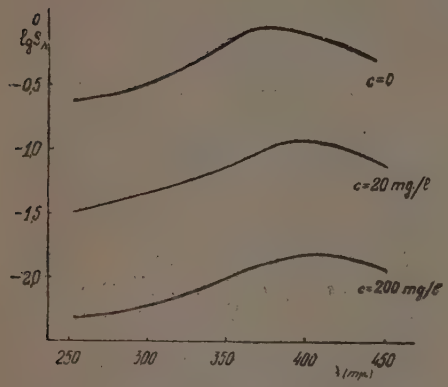


Fig. 1. Spectral distribution of natural sensitivity of lantern plates sensibilized by neocyanine at different concentrations of the sensibilizing bath.

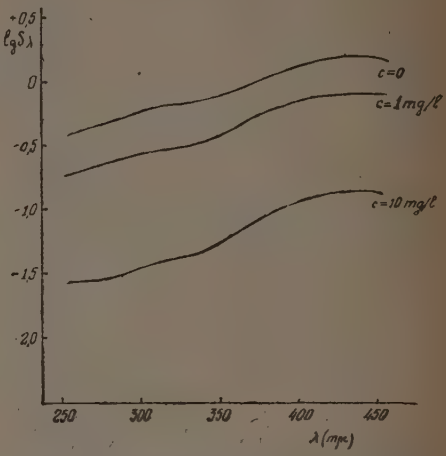


Fig. 2. Spectral distribution of natural sensitivity of ultra-rapid plates sensibilized by xenocyanine at various concentrations of the sensibilizing bath.

sensitometric measurements, which in this part of the spectrum is particularly low. It may therefore be considered an established fact that the desensibilizing action of sensitizers is not spectrally selective in nature.

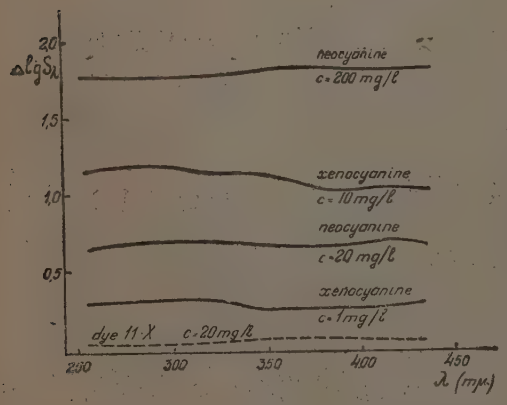


Fig. 3. Spectral distribution of the desensibilizing action of various dyestuffs

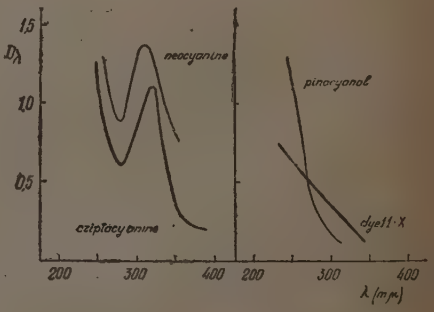


Fig. 4. Spectral absorption of stained gelatine films in the ultra-violet

Along with these, tests curves of spectral absorption in the ultra-violet region by the same dyestuffs in gelatine films were measured by means of Spekker's spectrophotometric appendage to a quartz spectrograph. As is seen from Fig. 4,

the optical density of the dyestuff layer (minus the density of the gelatine) grows in all cases with decreasing wave-length; moreover, in the case of neocyanine and kryptocyanine distinct bands of absorption with a maximum at $\lambda = 300—320$ mμ are even observed.

It will be obvious that absorption by dyestuffs in the region of natural sensitivity has a clear-cut spectral selective character. As, however, the desensibilizing action was found to be non-selective, we come to conclude that the filter effect is not the cause of desensibilization. Consequently, there is an analogy between the desensibilizing action of dyestuffs and that of inorganic ions absorbed by halogen-silver crystals of the emulsion.

Laboratory for Scientific Photography.
State Optical Institute.

Received
19. XII. 1942.

REFERENCES

[1] Ю. Н. Гороховский, Труды ГОИ, **14**, 321 (1941). [2] G. N. Gorokhovsky, C. R. Acad. Sci. URSS, XXXIX, № 7 (1943). [3] Lüppo-Cramer, Phot. Korr., **63**, 332 (1927). [4] А. И. Рабинович, Журнал физ. хим., **7**, 276 (1936). [5] М. М. Соболев, М. В. Бондарева и М. Ф. Евтеева, Журнал прикл. химии, **9**, 335 (1936). [6] I. I. Breido and G. N. Gorokhovsky, C. R. Acad. Sci. URSS, XXXVIII, 703 (1940).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1948. Volume XXXIX, № 9

GEOCHEMISTRY

COMPOSITION OF CELLULAR MEMBRANES IN RECENT AND FOSSIL LOWER PLANTS

By A. P. VINOGRADOV and E. A. BOICHENKO

(Communicated by V. G. Chlopin, Member of the Academy, 4.II.1943)

The variety of chemical composition, as shown by different mineral fuels, say oils, coals, etc., is largely accounted for by the variety in the composition of those groups of organisms which might have participated in their formation. Our knowledge as to the chemical composition of these organisms is; however, insufficient. In particular, we know very little as to the chemical composition of the cellular membranes in the unicellular plants — *Cyanophyceae*, *Heterocontae*, *Flagellatae*, *Chlorophyceae* etc. The membranes of those organisms make up a considerable portion of their bodies and are often well preserved in the oldest rocks, forming bituminous shales. In remote geological times, the Pre-Cambrian and the Early Cambrian, they may have been the main if not the sole sources of oil formation. Attempting to retrace the chemical composition of fossil organisms, we have set before ourselves the task of studying in a comparative way the composition of the membranes of some primitive forms of recent unicellular organisms, and mainly of those species which show a mass development (or flowering) in sea basins, or in fresh-water basins. At the same time; we studied the composition of membranes of such fossil organisms as *Gloeocapsomorpha prisca* in kukersite and *Botryococcus Braunii* in balkhashite.

The membrane composition was studied by means of microchemical reactions under the microscope and by means of michrochemical analyses: extraction with water and with organic solvents was applied; and also hydrolysis with acid and alkaline solutions. Colour reactions were also applied: a solution of $I_2 + H_2SO_4$ (for hemicelluloses), chlorine-zinc-water solution (for cellulose), Mangin's reagent (ruthenium-red) for pectinic substances, of fluoroglycine in HCl, etc. In this way over 150 recent and several fossil forms have been studied for the composition of their cellular membranes.

Flagellatae. The majority of *Chrysomonadales*, viz. *Chromulina Rosanoffi*, *Hydrurus foetidus*, *Sunura uvella*, *Uroglena volvox*, *Syncrypta volvox*, many of which show «flowering»; are covered with a membrane consisting of pectinic substances. Other *Chrysomonadales*, such as *Mallomonas caudata*, *Dinobryon sertularia*, contain along with pectinic substances also hemicelluloses. Of the *Cryptomonadales*, the membrane of *Cryptomonas erosa* contains pectinic substances only. The *Euglenae* have been found to possess a membrane made up of pectinic substances: *Astasia Klebsii*; *Trachelomonas hispida*, *Tr. volvocina*, *Colacium vesiculosum*, *Euglena gracilis*, *E. viridis*, *E. deses*, *E. spirogyra*, *E. acus*, *Lepocinclis ovum*, *Phacus caudata*, *Ph. pleuronectes*, *Ph. longicauda*. The last seven *Euglenae* were found to contain a small quantity of pectin mucus. The *Euglenineae* and *Protomastiginae* which have passed to animal mode of feeding and are partly devoid of chlorophyll

(certain *Phacus*, *Bodo*), also lose their pectinic membrane. Among the *Peridineae* there were species whose membranes contained pectinic substances, e. g. *Gymnodinium palustre*, or pectinic substances and hemicelluloses (*Ceratium cornutum*, *Peridinium tabulatum*, *P. Willei*). Lastly some species of *Glenodinium* were found to contain, aside from pectin and hemicelluloses, also cellulose (*Gl. cinctum*; *Gl. pulvisculus*). It is noteworthy that Eisenack found no cellulose in fossil *Peridineae*.

Cyanophyceae. The most primitive of the *Chroococcales*, which are known to cause mass «flowering» of entire water reservoirs and whose species not unfrequently serve as rock-forming material, were found to contain in their membranes pectinic substances. These are *Microcystis aeruginosa*, *M. flos-aquae*, *Coelosphaerium Kutzingianum*, *Aphanothece pallida*, *Merismopedia glauca*, *Chroococcus turgidus*. *Nostocales* that showed mass development, viz. *Anabaena flos-aquae*, *Aphanizomenon flos-aquae*, *Cylindrospermum stagnale*, *Nostoc pruniforme*, *Oscillatoria*, had pectinic membranes. Some other more complex species of *Nostocales*, viz. *Gloeotrichia echinulata*, *Gl. pisum*, *Scytonema Hofmanni*, contained in their membranes both pectinic substances and hemicelluloses. Finally, some species of *Stigonematales*; viz. *Hapalosiphon fontinalis*, *Stigonema ocellatum*, had in their membranes pectinic substances plus hemicelluloses. Hemicellulose appears in the mebranes of *Cyanophyceae* at a later stage of development; it is always present in species of higher organization, partly in the order *Nostocales* and especially in *Stigonematales*.

*Diatomeae**. In agreement with the observations of many authors, all of the *Diatomeae* investigated by us both sea- and fresh-water species (*Centrales* and *Pennales*), were found to possess a pectinic membrane.

Heterocontae. The most primitive *Heterochloridales* and *Heterococcales* (in which flowering was observed)—*Botryococcus Braunii*, *Chlorobotrys regularis*, had membranes consisting of pectinic substances. The *Heterosiphonales* (*Botrydium granulatum*, *B. Wallrothii*) and the *Heterotrichales* (*Tribonema bombycinum*) contained also hemicelluloses.

Chlorophyceae. In *Volvocales* we observed membranes consisting of pectinic substances in the following species: *Gloeococcus Schröteri*, *Volvox aureus*; *V. globator*, *Eudorina elegans*, *Pandorina morum*, *Gonium pectorale*, *Chlamydobotrys gracilis*, *Polytoma uvella*, *Chlamydomonas* (various species). In young forms, in *Chlamydomonas* in particular, cellulose is sometimes observed; it vanishes, however, in adult stages. Among the *Protococcales* we failed altogether to detect cellulose in *Dictyosphaerium pulchellum*. The rest of species contain in their membranes pectin plus hemicelluloses, and a certain amount of cellulose, from traces (*Protosiphon botryoides*, *Characium longipes*, *Ankistrodesmus falcatus*, *Chlorella vulgaris*, *Scenedesmus obliquus*, *Sc. quadricauda*, *Coelastrum microporum*, *Pediastrum Boryanum*, *P. duplex*) up to considerable quantities, as shown by the more complicated species, *Hydrodictyon reticulatum*. The amount of cellulose in the membranes of *Protococcales* increases with age.

In *Siphonales*, e. g. in *Caulerpa peltata*; *C. prolifera*, *Halimeda opuntia*, *Codium tomentosum*, we observed both pectin and hemicelluloses. In old filaments of *Vaucheria* species, especially in *V. geminata*, we found the membranes to contain also some cellulose.

In all *Ulotrichales*** and *Conjugatae**** the membranes were found to contain pectin plus hemicelluloses plus cellulose. We failed to discover the presence of cellulose in young stages.

It should be added that among *Rhodophyceae* (e. g. *Bangiales*—*Porphyra laciniata*, *Bangia fusco-purpurea*) and *Phaeophyceae* (e. g. *Ectocarpales*—*Chordaria*

* Species of *Melosira*, *Rhizosolenia*, *Asterionella*, *Diatoma*, *Fragilaria*, *Synedra*, *Cocconeis*, *Cymbella*, *Gomphonema*, *Gyrosigma*, *Navicula*, *Pinnularia*, *Nitzschia*.

** Species of *Cladophora*, *Oedogonium*, *Coleochaete*, *Gongrosira*, *Trentepohlia*, *Stigeoclonium*, *Chaetophora*, *Draparnaldia*, *Enteromorpha*, *Ulva*.

*** Species of *Penium*, *Closterium*, *Cosmarium*, *Hyalotheca*, *Spirogyra*, *Zygnema*, *Mougeotia*.

flaggelliformis, *Dictyosiphon foeniculaceus*); i. e. in the most primitively organized species out of the most primitive orders, we found no cellulose. We found cellulose in species of other orders of these algae; adult forms contained it in especially large quantities.

We had the occasion to observe directly that cellulose enters into the composition of the membrane in all *Bryophyta*. It is, however, the first time that the presence of lignin has definitely been proved for *Pteridophyta* (Table 1).

To sum up, we feel justified to assert that the most primitive species of the most primitive orders of all types of algae contain pectin in their membranes. As a general rule, cellulose is observed in highly organized species only. As an exception to this rule, we may cite the *Peridineae* and the *Volvocales*, among which there occur species containing at early stages of development cellulose in their membranes; at later stages the cellulose disappears.

Table 1

Composition of Cellular Membranes of Recent Lower Plants

Taxonomic position	Order	Pectins	Hemicelluloses	Cellulose	Lignin	Number of species analysed
Cyanophyceae	1. *Chroococcales*	+	—	—	—	6
	2. *Nostocales*	+	±	—	—	12
	3. *Stigonematales*	+	+	—	—	2
Rhodophyceae	4. *Bangiales*	+	±	—	—	2
	5. *Cryptonemiales*	+	+	—	—	1
	6. *Rhodymeniales*	+	+	±	—	2
	7. *Ceramiales*	+	+	±	—	1
Phaeophyceae	8. *Ectocarpales*	+	±	—	—	3
	9. *Laminariales*	+	+	+	—	5
	10. *Fucales*	+	+	±	—	4
Heterocontae	11. *Heterochloridales*	+	—	—	—	1
	12. *Heterococcales*	+	—	—	—	1
	13. *Heterosiphonales*	+	+	—	—	2
	14. *Heterotrichales*	+	+	—	—	1
Diatomeae	15. *Centrales*	+	—	—	—	2
	16. *Pennales*	+	+	—	—	12
Flagellatae	17. *Chrysomonadales*	+	±	—	—	7
	18. *Cryptomonadales*	+	—	—	—	1
	19. *Peridineae*	±	±	±	—	7
	20. *Euglenineae*	±	—	—	—	13
	21. *Protomastigineae*	—	—	—	—	2
Chlorophyceae	22. *Volvocales*	+	±	—	—	12
	23. *Protococcales*	+	±	±	—	12
	24. *Siphonales*	+	±	±	—	7
	25. *Ulotrichales*	+	+	+	—	16
	26. *Charales*	+	+	+	—	1
	27. *Conjugatae*	+	+	+	—	10
Bryophyta	28. *Hepaticae*	+	+	+	—	1
	29. *Bryales*	+	+	+	—	6
	30. *Sphagnales*	+	+	+	—	1
Pteridophyta	31. *Equisetales*	+	+	+	+	3
	32. *Lycopodiales*	+	+	+	+	1
	33. *Filicales*	+	+	+	+	3

Those of the species of lower organisms which are destitute of membranes; or whose membranes consist of pectinic substances, show a high content of total nitrogen, amounting to 10% per dry weight (Table 2).

In those cases when they are endowed with cellulose, the latter seems to «dilute» the concentration of nitrogen. The existence of plants with pectinic cellular membranes and with a high total nitrogen content makes doubtable the generally adopted opinion as to the high nitrogen content of some oils being due to their

Table 2

Nitrogen Content in Lower Plants

Taxonomic position	Organism	Nitrogen in dry weight %	Note
	Without cellulose		
Cyanophyceae	*Microcystis aeruginosa*	7.78	
	Nostoc commune	6.5	
	Anabaena	8.27	After Birge and Juday, 1922
	Aphanizomenon	8.01	
	Lyngbia	8.69	After Birge and Juday, 1922
	Oscillatoria	6.2	
Rhodophyceae	*Porphyra laciniata*	5.6	
	Bangia fusco-purpurea	4.0	
	Corallina officinalis	5.0	
Diatomeae	*Coscinodiscus*	4.5	
	Rhizosolenia calcar avis	3.6	
Flagellatae	*Euglena*	4.86	After Shiori and Mita, 1935
	Noctiluca mirabilis	7.07	After Emmerling, 1909
Chlorophyceae	*Volvox globator*	6.2	
	Ankistrodesmus	8.3	
	With cellulose		
Rhodophyceae	*Rhodymenia palmata*	2.8	Mean from 6 analyses by various authors
	Chondrus crispus	2.0	Mean from 8 analyses
Phaeophyceae	*Fucus vesiculosus*	1.64	Mean from 20 analyses
	Laminaria digitata	1.80	Mean from 18 analyses
Chlorophyceae	*Hydrodiction*	2.48	
	Cladophora	2.77	

animal origin. It is well known that the substance of combustible shales is made up of lower unicellular and colonial organisms (kukersite of *Gloeocapsomorpha prisca*, balkhashite of *Botryococcus Braunii*, kurongite of *Coelosphaerum* etc.). As shown above, the recent representatives of these lower organisms contain pectin in their membranes. We made an attempt directly to establish the nature of the substance constituting the membranes of the fossil forms listed above (Table 3).

It was found to swell in water, especially in slightly alkaline solutions, and to stain intensely with ruthenium-red. The reaction could not be brought about after the extraction of pectins from the membranes. Neither hemicelluloses, nor cellulose could be detected. The membranes were found to contain exclusively pectinic substances, which have heretofore been firmly believed to be rapidly decomposing carbohydrates. We are of the opinion that a much greater mass of pectinic substances of analogous organisms had served, owing to their high productivity, as a source for the formation not only of shales, but of oils, as well. This refers especially to the Pre-Cambrian and Early Paleozoic, during which these organisms might have played the chief part in the formation of caustobiolites. But we intend to discuss this subject at another occasion.

On account of some data as to the hypothetic presence of lignin in some *Phaeophyceae*, we obtained the ultimate products of successive treatment with benzene plus alcohol, alcohol, 10% HCl, saturated HCl of higher plants, on the one hand, and of *Laminaria digitata* and *Fucus vesiculosus*, on the other. We obtained also an unhydrolyzable fraction of the same plants when treated after Hilpert with 72% H_2SO_4 at—10° C. The two processes, both at the start and in the final products

Table 3

Composition of Cellular Membranes of Fossil Plants

Taxonomic position	Organism	Pectins	Hemicelluloses	Cellulose	Lignin	Containing rock
Cyanophyceae	*Gloeocapsomorpha prisca*	+	—	—	—	Kukersite, Silurian
Heterocontae	*Botryococcus Braunii*	+	—	—	—	Balkhashite, Quaternary
Chlorophyceae	*Pila scotica*	+	—	—	—	Boghead, Permian
Bryophyta	*Sphagnum* sp. . . .	+	+	+	—	Peat, Quaternary
Pteridophyta	1) Spores of ferns	+	—	—	—	Durenn, Carbon
	2) Tissue bits . .	—	—	+	+	Fusen lenses in it

(as; for instance ; in *Polygonum*); gave a positive reaction for lignin. In algae we failed to discover lignin either at the beginning of treatment, or in the final products.

W. I. Vernadsky Laboratory
of Geochemical Problems.
Academy of Sciences of the USSR.

Received
4. II. 1943.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

GEOCHEMISTRY

SPECTRUM ANALYSIS DATA ON CALCIUM-IRON-COPPER-BEARING MINERALS AND NATIVE SULPHUR FROM TARTARY

By L. M. MIROPOLSKY and S. A. BOROVICK

(Communicated by V. G. Chlopin, Member of the Academy, 6.III.1943)

In the territory of the Tartar Autonomous Soviet Socialist Republic calcite; pyrite and copper compounds are spread very extensively (1). Here and there one meets also with isolated accumulations of native sulphur (2), of ferruginous ochres and, rather rarely, of vivianite. Of them the first four are mainly associated with Permian formations, and the last two with the Neogenic and the Quaternary. Excretions of calcite, pyrite and copper compounds are observed threghout the profile, but those of native sulphur only in Upper Kazan layers.

The spectral investigation of these minerals had for object on the one hand, to ascertain with greater precision their chemical composition on different stratigraphic horizons for the most thoroughly investigated deposits, and, vn the other hand, to find out the distribution of individual elements and the effect of the variation of their composition on the appearance of certain typical morphological properties.

The specimens subjected to a qualitative spectrum anhalysis were: calcite, 6; pyrite, 3; ochre, 1: vivianite, 1; chalcosine, 3; malachite, 1; azurite, 1; red-brick ore, 1; sulphur, 1. We chose these minerals for the reason that they enjoy the most typical and peculiar properties.

The procedure of taking the spectrographs was as follows: the material was burnt in the flame of an an a. c. voltaic arc 220 V, 10 A; photograhs of the spectra of this flame were taken with a Ziss quartz spectrograph Q-24. From each specimen two spectrographs were taken in succession; the second of them gave an intensification of the lines of not easily volatile elements and of the lines of ionized atoms.

All specimens were tested for the following 56 elements: Li, Be, B, Na, Mg, Al, Si, K; Ca, Sc, Ti; V; Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge; As, Sr, Y, Zr, Nb, Mo, Ag, Cd, In, Sn, Sb, Te, Ba, La; Ce; Pr, Nd, Il, Sm, Eu; Gd, Tb, Dy, Ho, Er, Tu, Yb, Cp; W; Os, Ir; Pt; Tl; Pb and U.

Of them only 24 were found to enter in the composition of the tested minerals. These were: Be, B, Na, Mg, Al, Si; Ca, Ti; Cr; Mn, Fe, Co, Ni: Cu, Zn, Ga, Sr, Zr, Mo; Ag, In; Ba; Pb and U.

The data relating to these minerals are tabulated below.

From these data the following-conclusions can be made:

1. Some of the investigated minerals, e. g. sulphur, have a rather simple composition: a low content of accessory elements; which occur in negligible concentration; others; say; copper compounds and vivianite; are characterized by a more complicated composition; they contain up to 18 elements in different concentrations.

Place of sampling and main properties of the mineral	Age of the respective formation	Elementar l					
		Be	B	Na	Mg	Al	Si
1. Calcite from layer «Podlujnik», village Pechishchi, right bank of the Volga; transparent, colourless, with a slightly yellowish shade, bounded by the faces of a prism and a rhomboheder	$P_2^{kaz_2}$	—	—	—	b	—	1
2. Calcite from sulphur-bearing layer «Podlujnik», near village Sukeyevo, right bank of the Volga; white anhedral grains (in paragenesis with sulphur and gypsum)	»	2	—	1	B	C	C
3. Calcite from layer «Shikhany», near village Krasnovidovo, right bank of the Volga; yellow-brown, in the form of stalactites	»	—	—	—	C	5	1
4. Calcite from layer «Sloisty Kamen», near village Pechishchi; transparent, yellowish, bounded by faces of an acute rhomboheder	»	—	—	b	C	—	1
5. Calcite from limestone cavity, near village Kichuchatovo, right bank of the Kichuy; transparent, slightly yellowish, bounded by the faces of a scalenoheder and rhomboheder	$P_2^{kaz_1}$	—	—	—	C	4	3
6. Calcite from «recrystallized limestone» cavities, near village Sokolyi Gory, right bank of the Kama; transparent, colourless, bounded by faces of an obtuse rhomboheder	P_1A	—	—	3	C	—	2
7. Pyrite from layer «Podlujnik», near village Sukeyevo, bounded by cubic faces	$P_2^{kaz_2}$	—	—	b	b	3	C
8. Pyrite from limestone cavities, near village Sarabikulov, on river Sheshma; bounded by cubic and octaheder faces	$P_2^{kaz_1}$	—	—	2	3	a	2
9. Pyrite from «recrystallized limestone» cavities, near village Sokolyi Gory; bounded by cubic faces	P_1A	—	—	—	3	4	—
10. Ochre from «Kisicheskoe boloto» peat, near Kazan; red-brown, friable	Q_2	—	—	C	2	a	B
11. Vivianite from superficial formation in a clay near village Zmievo, district of Chistopol	N_2	—	4	C	B	C	B
12. Chalcosine from cupriferous dolomite limestone on mount Krasnyi Mys, near village Krasnovidovo; black, dense	P_2^{tat}	—	—	1	1	2	C
13. Chalcosine from concretions in bed «B», near village Kullarovo, along the left bank of r. Sardyk; black, dense	$P_2^{kaz_2cont}$	—	—	2	2	2	C
14. Malakhite from the superficial formations in the limestone, near village Asan-Elda; green, finely fibrous	»	—	—	b	C	b	B
15. Azurite from crusts along fissures in sandy argillite, near village Neratovka; blue, crystallized	»	—	—	1	b	2	C
16. Red-brick ore from concretions in the bed «B», near village Kullarovo	»	—	1	a	1	1	B
17. Sulphur from the sulphur-bearing layer «Podlujnik», near village Sukeyevo; yellow, in the form of anhedral grains	$P_2^{kaz_2}$	—	—	—	3	—	1

Symbols for the intensity of lines in spectrographs: A—extremely strong, B—very
4—negligible traces, 5—barely visible.

composition

Ca	Ti	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Sr	Zr	Mo	Ag	In	Ba	Pb	U
A	1	—	1	1	—	—	4	—	—	—	—	—	—	—	—	—	—
A	C	—	a	B	—	1	1	—	—	2	1	—	—	—	—	4	3
A	a	—	2	b	—	—	a	—	—	C	—	—	—	—	—	a	3
A	1	—	1	—	—	—	—	—	—	a	—	—	—	—	—	—	—
A	a	—	1	b	—	—	—	—	—	—	—	—	—	—	—	—	—
A	1	—	1	a	—	—	—	—	—	b	—	—	—	—	—	4	—
2	3	—	2	A	—	—	5	—	—	b	—	—	—	—	—	—	—
—	—	—	2	A	—	—	4	—	—	—	—	—	—	—	—	—	—
—	2	—	3	A	—	—	4	—	—	—	—	—	—	—	—	—	—
1	2	—	a	A	—	1	1	—	—	—	—	—	—	—	—	2	b
C	C	b	C	A	1	b	1	4	2	—	—	—	—	—	a	b	C
2	1	1	b	B	—	—	A	3	—	2	—	2	b	—	b	a	2
1	2	—	1	B	—	—	A	—	—	2	—	2	a	—	a	b	1
C	1	2	b	C	—	—	A	—	—	b	—	1	b	—	C	1	b
b	1	—	1	a	—	2	A	—	—	—	—	—	2	2	—	b	—
1	1	2	1	B	—	4	A	2	—	—	—	b	b	—	b	b	b
3	—	—	—	3	—	—	2	—	—	—	—	—	—	—	—	—	—

strong, C—strong, a—above medium, b—medium. 1—weak, 2—very weak, 3—traces,

2. With regard to the association of the elements they contain; the analysed minerals fall distinctly into three groups: a) sulphur, as a mineral of the simplest composition; b) calcite, pyrite, and ferruginous copper, as minerals of more complicated composition, and near to one another in their complex of elements: c) copper compounds and vivianites which are minerals of still more complicated composition and display a somewhat peculiar association of accessory elements.

3. The elementary chemical composition of the minerals taken from different stratigraphic horizons and from different beds shows certain variations, quantitative as well as qualitative. Mention needs to be made of the presence of Be, Ni, Cu, Sr, Ba, Pb, U in calcite, of Na, Sr in pyrite, of Cr and Zn in chalcosine.

4. In calcite specimens, along with calcium, which is the leading element, there always occur Mg, Si, Ti, Mn; the concentration of Mn, Fe is rather high; sometimes one finds Sr, Si, Al, Ti, Na, Mn, Cu, Ba and admixtures of Pb. Rarely Be, Ni, Zr and U.

5. In pyrite specimens, along with Fe, one always finds Mg, Al, Mn, Cu, sometimes Si, Na, Mg, Sr and admixtures of Ca and Ti.

6. The concentration of Na, Al; Si, Mn, partly of Cu, Ca, is higher in ochre than in pyrite; Ni, Pb and U are present; no Sr.

7. Vivianite, in contradistinction to pyrite, shows a very considerable concentration of Na, Mg, Al, Si, Ca, Ti, Mn, partly of Cu; considerable quantities of U; Ba, Cr, Ni, Pb and traces of Ga, Zn, B are present; Sr absent.

8. Cupriferous excretions, besides Cu, always contain Na, Mg, Al, Si, Ca, Ti, Mn, Fe, Ag, Pb; the concentration of Fe, Si, sometimes of Mg, Ca, Ba, Pb, U, Na, Ag and rarely of Mn, Al, Mo, Sr is rather high; B, Cr, Ni, Zn and In occur in traces.

9. In sulphur only traces of Si, Cu, Mg, Ca and Fe have been detected.

10. As regards the distribution of the elements in the mineral investigated, one may distinguish the following groups:

a) Elements that are nearly always present—Mg, Si (with the exception of specimen 9), Ca (except sp. 9), Mn (except sp. 17) and Fe (except sp. 4).

b) Frequently occurring elements—Ti (15 specimens out of 17 contain it), Cu (in 14 out of 17), Al (in 13 out of 17), Na (in 11), Pb (in 10), Sr (in 8), U (in 7).

c) Sporadically observed elements are Ba, Ni, Ag, Cr, Mo, Zn, B, Be, Co, Ga, Zr and In.

11. Most of the elements enter into the mineral lattices in the form of isomorphous admixtures, sometimes isovalent, in certain cases heterovalent, according to the principle of compensational and polarly directed isomorphism.

12. The presence of certain elements, e. g. of Si, Fe and Al, in some of the minerals is probably due to microinclusions, say, of quartz, chalcedony, opal, hydrogoethite, and silt components.

Unfortunately, we have not yet been able to determine the influence of a changed composition on the appearance of morphological characters in the minerals investigated.

State University.
Kazan.

Received
6. II. 1943.

REFERENCES

[1] Л. М. Мирольский, Учен. зап. Каз. гос. ун-та, **98**, кн. 1 (1938). [2] Л. М. Мирольский, там же, **95**, кн. 3—4 (1935).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

GEOLOGY

DEVONIAN *STROMATOPORELLIDAE* AND THEIR RÔLE IN THE STUDY OF THE STRATIGRAPHY OF THE KUZNETSK BASIN

By V. I. YAVORSKY

(Communicated by P. I. Stepanov, Member of the Academy, 21.IX.1942)

Representatives of the genus *Stromatoporella* from the group *Millepora* have been paid very little attention by paleontologists, as may be seen from the review of the respective literature.

The genus *Stromatoporella* was established by Nicholson in 1886. In his classical work (1) we find the description of 6 Devonian species of the genus: *Stromatoporella selwinii* N.; *Str. recialis* N.; *Str. damnoniensis* N.; *Str. elfallensis* N.; *Str. solitaris* N. and *Str. curiosa* N.

From this it may be supposed that in the Devonian of England these forms were developed extensively, but have not been discovered to full extent; owing probably to the scarcity of the collections yet made. Other authors, while dealing with *Hydrozoa*, have scarcely touched upon this genus.

From literary data one may conclude that *Stromatoporellidae* occur exclusively in the Devonian and only in its middle and upper portions. As, however, the knowledge concerning their distribution is scanty; it is hard to say whether they are dispersed throughout the beds of this age or only locally. From the available materials one may infer the occurrence of *Stromatoporella* in the Devonian of the Urals and of Kazakhstan. A mass occurrence the representatives of this genus enjoy among the Devonian formations developed on the borders of the basin of Kuznetsk; Dehorne (2) reported the presence of *Stromatoporella* in the Mesozoic (Jurassic). This is hardly probable; however.

Aside from characterizing the outer features of the skeleton peculiar to this genus; Nicholson in his monograph also describes the microstructure of its typical skeletal fibres. Thus; he points out that the fibres of the tissue are fine; porous; or pervaded by irregular microscopic tubes (Plate I; Figs. 4—5; Plate LI; Fig. 1—4). In their tangential section many empty rings are visible with the same typical microstructure of walls. It may be added that among their typical characters are the superimposed astrorhizae; and a peculiar structure of the astrorhizal cylinders connecting them. No detailed description of the microstructure of fibres is given by Dehorne for the two species: *Stromatoporella hydrastinoides* and *S. haugi*. A. Steiner (3) mentions to have examined several specimens from the Dehorne's material, relating to *S. haugi*, in which she always observed a structure which she describes as «water column». This structure is utterly different from that given by Nicholson for the Palaeozoic genus *Stromatoporella* established by him. Therefore Dehorne is likely to be wrong in referring these forms to *Stromatoporella*. These forms; as the microstructure of their tissue fibres does not; as is evident from the conclusion of A. Steiner; correspond to that of the Palaeozoic representatives of *Stromatoporella*, should certainly belong to a new genus.

The investigation of the *Stromatoporaidea* fauna makes slow progress and is far from having embraced the representatives from all systems. Thus, only very few of them were described from the deposits of the Carboniferous system, and still fewer from the Permian. There can be no doubt, however, but that they do occur there; they appear to be richly represented, for instance, in the Artinskian limestones of the Urals.

From the available description of *Stromatoporaidea* it is obvious that the Palaeozoic forms are distinguished by a strikingly different microstructure of their skeletal tissue fibres, from the Mesozoic forms [1].

Just where this change of structure takes place—at the boundary between the Palaeozoic and Mesozoic or in the upper strata of the Palaeozoic—is a question which cannot be decided until the representatives of this fauna from Permian deposits have been investigated.

Concomitant to changes of textural microstructure is the disappearance of certain genera of *Stromatoporaidea*. Neither the genus *Actinostroma*, nor *Glathrodictyon*, nor *Stromatoporella* are to be found in the Mesozoic, for instance. With respect to *Glathrodictyon* there is sufficient evidence to assume that they were very infrequent, even in the Middle Devonian, and did hardly pass into the Upper Devonian. On the other hand, *Stromatoporella* have, as recorded above, reached an extensive development in the Devonian. Yet, all these questions cannot be solved definitely until the *Stromatoporella* will be studied on a vaster scale. It is of interest to note that, judging by the material at hand, some forms of *Stromatoporella* show a steady occurrence in the Devonian of the Kuznetsk basin, not only in its sections, but also in its horizons; and accordingly may serve as reliable stratigraphical characteristic.

The description of some of the representatives of this genus has already been given in my earlier work. In 1941 I finished and had ready for press a monograph which contained a description of 20 new species of *Stromatoporella*.

Their distribution among the Middle Devonian formations of the south-western border of Kuznetsk basin is as follows:

Zhivetcan stage

Indospirifer horizon:

Stromatoporella loutouguini Yavor.
Str. convicta sp. nov.
Str. batschatensis sp. nov.
Str. boutovi sp. nov.
Str. volteschensis sp. nov.
Str. kuznetskensis sp. nov.
Str. regularis sp. nov.
Str. gapeevi sp. nov.
Str. abensis sp. nov.
Str. nudata sp. nov.
Str. basili sp. nov.
Str. ussowi sp. nov.

Chaskotirisian horizon

Stromatoporella batschatensis sp. nov.
Str. mamelosa sp. nov.

Eifel stage

Stromatoporella tchernyshevi sp. nov.
Str. tyrganensis sp. nov.
Str. tchernychevi Yavor. var. *Kostenkovensis* var. nov.
Str. chomutinkensis sp. nov.
Str. insolita sp. nov.
Str. devonica sp. nov.
Str. dolitaria Nich.

It is worthy of note that among the large collection of *Stromatoporella* which I possess; not a single representative of it has been known from the Koblenz stage or from the formations of the Lower Devonian or Silurian.

Received
21. IX. 1942.

REFERENCES

[1] H. A. Nicholson, A monograph of the British stromatoporoids. [2] Yvonne Dehorne, Les stromatoporoïdées des terrains sécondaires. Mémoir pour servir à l'explication de la carte géologique détaillée de la France (1920). [3] A. Steiner, Mém. de la Soc. Vaudoise des Sc. Nat., 4, No. 3 (1932).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1943. Volume XXXIX, № 9

MICROBIOLOGY

EXPERIMENTAL INOCULATION OF LEPRA TO WHITE MICE PREVIOUSLY MADE SENSITIVE BY FILTRATES OF THE SKIN OF LEPROUS PATIENTS

By A. J. JOLKEVICH

(Communicated by N. F. Gamaleya, Honorary Member of the Academy, 30.X.1942)

Leprosy belongs to those poorly studied and insidious diseases with respect to which we possess neither efficacious curative methods; nor reliable procedures of inoculating test-animals. The isolated cases of inoculation that had succeeded once or twice to such notorieties of science; as Kedrowsky; Klegg; Bayon; Duval and others; were never reproduced and have therefore remained unrecognized.

From my observations of patients affected with leprosy I arrived at the conclusion that this disease is based on an insufficiency of the cutaneous apparatus. At our latitudes this insufficiency becomes most commonly manifest as result of a shock of the cutaneous covering; due either to sudden and sharp chill; or to continuous cooling.

The agent of leprosy is endowed with dermotropic properties. The skin of leprous patients is found to be saturated with leprobacilli and to contain products of their life activity and toxins discharged by them.

It stands to reason that; similar to tuberculosis; leprosy should be accompanied with profound changes in the reactive apparatus of the skin; i. e. with a specific allergy.

In order to isolate leprotoxins; as well as those substances that are responsible for the specific leprous allergy; we prepared extracts by grinding infiltrated skin areas and cutaneous lepromas in the cold in a physiological solution of sodium chloride. The extracts were filtered through Seitz filters.

The filtrates were used to make the mice sensitive before inoculation. The first injection was made intraperitoneally; it was followed by five subcutaneous and intracutaneous injections; made in the lumbar region. The injections were practised at 2—3 day intervals.

Description of the Experiments. Series 4. Eight mice were treated; four of them with filtrates; prepared from human skin; and the other four with filtrates from mouse skin. Inoculation was made twice; on the 11th and 14th day upon the first injection of the filtrate. An emulsion freshly prepared from lepromas was treated with unfiltered X-rays (500 r) and at once introduced to the mice intraperitoneally at minimum doses. Six mice have survived the treatment. Five of them proved infected. In a month upon inoculation ulcers appeared on the skin of the back; sacrum; hips; occiput; neck and near the eyes, their size ranging from that of a needle puncture to $1^1/_2$ mm across. The ulcers were round in shape; with a clean smooth bottom and even edges; they gradually became covered with scabs. Smears and histological sections; prepared from the skin taken from the regions of ulcers; were found to contain a multitude of acido-resistant bacilli; localized mostly in the hair follicles. Three mice perished from intestinal infections; two were sacrificed. One of the latter showed general ema-

ciation and loss of hairs all over the body, elephantiasis of the left hind extremity, and ceratitis of the right eye. During the last days there appeared, moreover, oedema of the tail and of the external sex organs. The second mouse developed paresis of the whole posterior half of the trunk. The hairless sacrum had a pronounced cyanotic colour.

Greyish milliary and submilliary nodules have been discovered in the liver; spleen; epiploon; mesentery; in the membranes of the peritoneum. On the wall of the caecum and of the processus vermicularis some of the nodules had the appearance of outgrowths. In one of the mice that had also been inoculated intraperitoneally; there was found a nodule under the skin at the side surface of the neck.

Series 8/3. Like in the series described above; the mice of this series were made sensitive with filtrates prepared from human skin. The only difference consisted in that the filtrates applied in series 8/3 have not been freshly prepared; but were stored during $2^1/_2$ months. Out of the 6 mice under experiment 5 fell ill. Those of them that perished within four months after inoculation showed no cutaneous exulcerations; except one mouse which survived during 4 months and 10 days; this one developed ulcers upon the skin of the back.

Milliary and submilliary nodules have been discovered mainly in the mesentery; epiploon; peritoneum and the walls of the viscera; as well as on the liver and partly on the spleen. In one case of intraperitoneal inoculation there was developed a nodule in the region of the neck.

Series 2. The mice of this series were preliminarily treated with filtrates; prepared of the skin of a mouse sensibilized with Hansen's bacilli by the method described in an earlier note (1). Inoculation with small doses of leproma emulsion was made intraperitoneally thrice a month. Two months after the last injection one of the mice showed two round ulcers with a smooth and clean bottom; arranged symmetrically on each side of the spine upon the skin of the back in the interscapular region. In the smears and sections prepared from the ulcers; there were found abundant acidoresistant bacilli; localized mostly in the hair follicles. In the mesentery; epiploon and liver nodules have been found in 4 cases out of 5.

Results of Histological Examination. The nodules are formed mostly along the course of vessels; and consist of tissue of granulomatous character. In those mice that perished within the first three months following inoculation; the granulomas consisted of epithelioid cells whose cytoplasm was a reticular structure; reminding that of a honeycomb. In the centre of the granuloma there is kariorhexis and pycnosis of the nuclei. The necrotic masses; as well as the epithelioid cells; contain abundant acidoresistant bacilli; arranged both in small groups and in large accumulations; having the appearance of globules.

According to Kedrowsky (2); the presence of epithelioid cells «stuffed with acidoresistant bacilli is so typical of the leprosy; that this character can be considered as a decisive one». We were able to become convinced of the validity of this statement of Kedrowsky. The epithelioid cells are undoubtedly an intermediate stage in the development of the foamy Wirchow cells. In our experiments with mice that perished at early dates (within 3 months after infection) the process was arrested in most cases at the time of formation of the epithelioid cells. In those cases when the mice survived 3-4 months, we could observe transitions from the epithelioid cells to the formation of foamy cells. In this case necrotic alterations in the granulomas were either absent, or very feebly expressed. The protoplasm of the epithelioid cells assumed a honeycomb-like structure. When stained with sudan and Ziel's fuchsine, the cell vacuoles were found to contain lipoids and accumulations of acidoresistant bacilli, typical of the lepra.

Irkutsk Clinical Leprosorium.
Department of Medical Microbiology at the Irkutsk Medical Institute.

Received
30. X. 1942.

REFERENCES

1 A. J. Jolkevich, C. R. Acad. Sci. URSS, XXXIX, No. 6 (1943). 2 В. И. Кедровский, Сборн. «Перспективы борьбы с прокавой», стр. 165 (1929).

Prix $ 0.50